CSIRO Division of Food Research

Institute of Animal and Food Sciences

Report of Research 1980–81

DIVISION OF FOOD RESEARCH

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Graham Road, Highett, Vic.
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Telex: 33766

Officers also located at

The Russell Grimwade School of Biochemistry,
University of Melbourne, Parkville, Vic. 3052.
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Meat Research Laboratory (MRL)

Corner Creek and Wynnum Roads, Cannon Hill, Qld.
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Telephone: (07) 399 3122
Telex: 40150

Officers also located at

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Telex: 92178

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Corner Flemington Road and Park Drive, Parkville, Vic.
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Telex: 32677

Hawkesbury Agricultural College,
Richmond, NSW 2753.
Telephone: (045) 70 2231

Industry and Consumer Liaison Officers, to whom inquiries may be directed, are listed on page 118 of this Report.

Laboratory operated jointly by CSIRO and NSW Department of Agriculture

Gosford Horticultural Postharvest Laboratory,
Pacific Highway, West Gosford, NSW.
Postal address: PO Box 355, Gosford, NSW 2250.
Telephone: (043) 24 3844

Front cover: Queensland fruit fly, one of Australia's worst horticultural pests, infesting a Washington Navel orange

Commonwealth Scientific and Industrial Research Organization
Australia

DIVISION OF FOOD RESEARCH

A Division of the Institute of Animal and Food Sciences

Report of Research

1980/81

Sydney

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When the Council for Scientific and Industrial Research, which was to become CSIRO, was established in 1926, one of the first areas of investigation was the preservation and transport of food. In 1932, CSIR formed a Section of Food Preservation and Transport to work on problems in the storage and distribution of meat and fresh fruit. The success of this work laid secure foundations for developing export industries based on these and other primary products.

In 1938 the Section's headquarters was moved from Brisbane, Queensland to Homebush, New South Wales. At the same time the scope of its research in food science and technology was broadened: studies on fish and eggs were begun, while meat research continued at the Brisbane Laboratory. During the Second World War, research was concentrated on problems of canning and drying foodstuffs. In 1941 the Section became the Division of Food Preservation and Transport. Twenty years later, the Division moved into new headquarters at North Ryde, New South Wales.

Meanwhile, a separate but parallel development was taking place in dairy research. In 1929 CSIR awarded an overseas studentship for research in dairying and dairy manufacture. A Dairy Research Section was formed during the Second World War, and this became the Division of Dairy Research in 1962. Early successes included advances in the mechanization of cheese manufacture.

In 1971, the Divisions of Dairy Research and Food Preservation and Transport were amalgamated to form the Division of Food Research, with three main laboratories.

The Food Research Laboratory (FRL) at North Ryde, New South Wales, erected in 1961, has laboratories for chemistry, biochemistry, physics, microbiology, plant physiology and food technology, a series of controlled temperature rooms, a food processing and packaging pilot plant, and facilities for plant growth in controlled environments. A Plant Physiology Group is maintained in the School of Biological Sciences at Macquarie University. The Headquarters of the Division is located in FRL.

The Meat Research Laboratory (MRL) at Cannon Hill, Queensland, erected in 1967 (Stage I) and 1969 (Stage II), has laboratories for chemistry, biochemistry, physics, microbiology, animal physiology and electron microscopy, a series of controlled temperature rooms, a meat processing pilot plant, and animal handling facilities.

The Dairy Research Laboratory (DRL) at Highett, Victoria, erected in 1955 and extended 1970, has laboratories for chemistry, biochemistry and microbiology, and a comprehensive pilot plant for processing milk products.

In addition, the Division maintains a Food Research Unit concerned mainly with seafoods at the CSIRO Tasmanian Regional Laboratory, Hobart, and operates, in conjunction with the New South Wales Department of Agriculture, the Gosford Horticultural Postharvest Laboratory.

When the Divisions of CSIRO were grouped into five Institutes in 1979, the Division of Food Research became one of the constituent Divisions of the Institute of Animal and Food Sciences.

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FOOD RESEARCH 1980-81

General review

Introduction

Following the completion of an external review of the Dairy Research Laboratory, Mr L.L.Muller was appointed Officer-in-Charge of the Laboratory and an Assistant Chief of the Division of Food Research. Mr Muller was appointed to CSIRO in 1958 and had been Acting Officer-in-Charge of the Dairy Research Laboratory since January 1979.

Since joining CSIRO, Mr Muller's research activities have been mainly in the development of processes for the manufacture of such dairy products as casein, co-precipitates of casein and whey proteins, and recombined sweetened condensed milk. In recent years he led a group examining the problems of whey utilization, with a particular interest in applications of membrane technology.

On 24 July 1980 the Chairman and Members of the CSIRO Executive hosted a function to mark the official opening of the new processing facility at the Meat Research Laboratory, Cannon Hill. The facility was opened by the Minister for Science and the Environment, the Hon. David Thomson MC, MP, and the ceremony was followed by an inspection of displays showing the research work of the Laboratory.

Guided tour of new processing facility

The project was financed jointly by CSIRO and the Australian Meat Research Committee.

The facility will enable engineering research and development work to be done under conditions which reasonably simulate throughput in a commercial abattoir. The new facility consists of animal holding yards, a slaughtering and dressing area, chillers and freezers, and a processing area for

boning and packing. There is adequate space for the demonstration of equipment and processing techniques to industry personnel. Further details are given on page 60 of this Report.

Finance

The Division is funded mainly from Appropriation sources, but a significant proportion of the research is funded by Commonwealth and State departments, statutory bodies and the food industry.

Sources of Funds	$
Appropriation Funds	6,865,785
Contributory Funds	
MRL	
Australian Meat Research Committee	
General Contributions	405,000
Industry Section	407,875
Pig Industry Research Committee	3,861
DRL	
Dairying Research Committee	251,711
Department of Productivity Grant	51,000
Schreiber Foods Inc.	19,236
UHT Manufacturers	18,172
FRL	
Australian Apple and Pear Corporation	29,832
Australian Chamber of Shipping	3,007
Australian Chicken Meat Research Committee	33,000
Australian Development Assistance Bureau Bhutan Project	139,606
Commonwealth Special Research Grants	
Department of Primary Industry	17,667
Australian Citrus Growers Federation	8,000
National Peanut Council of Australia	9,667
Dried Fruits Research Committee	11,163
Fishing Industry Research Committee	72,935
National Health and Medical Research Council	7,619
NSW Department of Agriculture	67,681
Poultry Research Advisory Committee	15,711
Rural Credits Development Fund	36,378
Donations from the Food Industry	16,416
Total Operating Funds	$8,491,322

Staff

Composition and location of staff, including vacant positions, apprentices and staff employed for limited periods on development projects, casual labour and the Special Youth Employment and Training Program (SYETP), at 30 June 1981 was as follows:

Location	Professional Staff	Other Staff	Total
Headquarters			
North Ryde	3	1	4
FRL			
North Ryde	79	71	147
Macquarie University	7	4	11
Gosford	-	1	1
Hobart	6	5	11
MRL			
Cannon Hill	34	45	79
Melbourne	1	1	2
Perth	1	1	2
Sydney	1	1	2
DRL			
Highett	30	43	67
University of Melbourne	2	1	3
Total	164	174	338

Appointments

The following appointments were made to the Division:

DRL

Miss Kim Thu Nguyen Thi, Experimental Officer - Cheese Productivity Project.

FRL

Mr G.S.Heard, Experimental Officer, Food Safety and Nutritional Quality Group - to work on biotin and the Sudden Infant Death Syndrome (funded by grant from National Health and Medical Research Council).

Mrs Thi Hoa Ly Nguyen, Experimental Officer, Food Structure Group - to conduct fundamental studies on the constituents of hen's eggs and on properties likely to be of commercial importance (funded by grant from Poultry Research Advisory Committee).

Miss E.Pittman, Experimental Officer, Chemical Bases of Food Acceptance Group - to study the perception of odour mixtures and delayed bitterness in orange juice.

Miss J.A.Statham and Mr S.J.Sykes, Experimental Officers, Tasmanian Food Research Unit - to work on the development of fish handling processing and packaging systems, and their influence on the quality of Australian seafood products (funded by grant from Fishing Industry Research Trust Account).

MRL

Mr J.Buhot, Experimental Officer, Industry Section - to assist in studies of energy conservation and the development of new technology.

Cessations

The following officers ceased duty with the Division:

DRL

Mr D.Jones, Experimental Officer - worked on oxidation problems in milk powders.

Mr I.B.Powell, Experimental Officer - Cheese Starter Group.

FRL

Mrs M.B.MacAllister, Librarian - transferred to CSIRO Institute of Earth Resources.

Mr J.A.Doran, Senior Laboratory Craftsman - retired after 20 years' service with the Division.

Mr N.S.Dettmann, Senior Laboratory Craftsman - retired due to ill health, after seven years' service with the Division.

MRL

Dr B.V.Kavanagh, Research Scientist, and Mr S.P.Moodie, Experimental Officer - Process Engineering Group.

Mrs A.L.Ford, Experimental Officer - Meat Science and Technology Group.

Deaths

The death occurred on 16 May 1981 of Mr Jack Shipton, Principal Research Scientist, FRL. Mr Shipton joined the Organization in 1943 and worked broadly in the areas of dehydration and freezing of foods and in flavour chemistry. From 1951 to 1958 he was seconded to the Department of Commerce and Agriculture as Chief Food Technologist, Defence Food Section, and to the Department of Trade, and was involved in the development of the Army Food Research Establishment at Scottsdale, Tasmania. For the past two years he had acted as Scientific Assistant to the Officer-in-Charge, FRL.

Mr E.J.Haynes, Senior Laboratory Craftsman, MRL, died suddenly on 1 December 1980, after 17 years' service.

Honours and awards

In June 1980 Dr J.H.B.Christian, Chief of the Division, was elected Chairman of the International Commission on Microbiological Specifications for Foods, of which he had been a member since 1971. In November 1980 he accepted appointment for a second five-year term to the World Health Organization Expert Advisory Panel on Microbiological Aspects of Food Hygiene.

The 1980 Australian Society of Dairy Technology Silver Medal - the Loftus Hills Dairy Science Award - was presented to Dr G.R.Jago, Senior Principal Research Scientist, DRL, for published work on the metabolism of cheese starter streptococci.

Mr P.W.Board, Principal Research Scientist, Applied Food Science Group, FRL, was awarded the 1981 Award of Merit of the Australian Institute of Food Science and Technology (AIFST). Dr D.J.Walker, Officer-in-Charge, MRL, was elected a Fellow of the AIFST.

Mr J.B.Davenport, Principal Research Scientist, Food Structure Group, FRL, was elected a Fellow of the Australian

and New Zealand Association for the Advancement of Science (ANZAAS).

Mr G.R.Chaplin, Experimental Officer, FRL, was the recipient of a CSIRO Overseas Study Award for 1980, and Mr D.R.Smith, Extension Officer, MRL, received a similar Award for 1981.

Miss P.L.Conway, Experimental Officer, FRL, was awarded the Sherris-ASM Scholarship for 1981 to assist in undertaking studies on interactions of pathogens with the gut microflora at the Tufts Medical Centre, Boston, Mass., USA, for three months.

Dr D.Graham, Senior Principal Research Scientist, FRL, was appointed Secretary/Treasurer of the International Association for Plant Physiology.

Degrees were conferred on the following staff:

Mr J.G.Zadow - D.Appl.Sc. (Victoria Institute of Colleges)
Dr W.G.Murrell - D.Sc.Agr. (University of Sydney)
Mr L.R.Fisher - Ph.D. (University of New South Wales)
Mr M.B.Smith - D.Sc. (University of New South Wales)
Mr M.J.Eyles - Ph.D. (University of Sydney)
Mrs Lesley C.Wright - M.Sc. (Macquarie University)
Miss Elizabeth Pittman - B.Sc. (Macquarie University)

Guest workers

The Division's Laboratories were visited by many research workers from institutions and universities both in Australia and overseas. The following spent three weeks or more at one of the Laboratories:

At FRL

Dr Y.Ueda, University of Osaka, Japan - worked on aspects of cell wall enzymes in ripening tomato.

Dr Chee Choon Seow and Dr Lim Chin Lam, University of Science of Malaysia, Penang - collaborative research in Applied Food Science Group.

Dr G.C.Gibbons, Carlsberg Research Center, Copenhagen, Denmark - work on chlorophyll fluorescence.

Mr F.Geiser, University of Hohenheim, Stuttgart, West Germany - working on temperature effects on lipids in hibernating animals (in collaboration with Dr S.Augee of University of New South Wales).

Miss C.Booth, Royal Alexandra Hospital for Children, Sydney - studied amines related to gastro-intestinal disorders.

Sister Mary Drum, Department of Primary Industry, Papua New Guinea - developing skills in postharvest physiology and technology of fruits and vegetables.

Mr M.V.Capanzana, Food and Nutrition Research Institute, Philippines (completing Graduate Diploma in Applied Sciences, Hawkesbury Agricultural College, Richmond, NSW) - work experience in Applied Food Science Group, North Ryde, and at Tasmanian Food Research Unit (TFRU), Hobart.

Mrs Sing Ching Tongdee, Thailand Institute for Scientific and Technological Research - studies of tropical fruit storage and handling.

Mrs Sing Ching Tongdee investigating fungi associated with rotting in litchis

Miss Sharifah Nor Hidayat Alkaff, Malaysian Agricultural Research and Development Institute, Trengganu, Malaysia - collaborative research on fish handling, processing and preservation systems (at TFRU, Hobart).

At MRL

Dr A.J.Møller, Royal Veterinary and Agricultural University, Copenhagen, Denmark - collaborative research in Meat Science and Technology Section.

Assistant Professor T.Nakayama, Mie University, Japan - Meat Science and Technology Section.

Dr T.Suzuki, University of Agriculture, Tokyo, Japan - Meat Science and Technology Section.

Dr D.Hamilton, University of Queensland, Brisbane - Muscle Growth and Development Section.

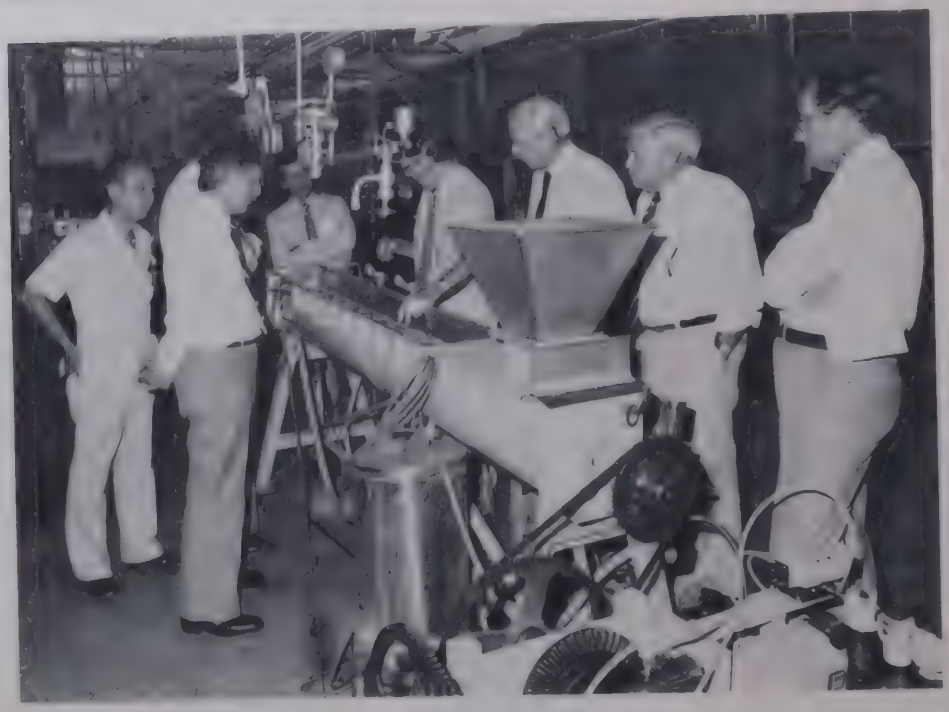
Miss Alkaff and
Dr June Olley, Leader,
TFRU

Visitors

The Division welcomed many other visitors for brief periods. They included:

Dr R.R.Selvendran, ARC Food Research Institute, Norwich, UK.
Dr Bent Enevoldsen, Department of Brewing Chemistry, Carlsberg Research Center, Copenhagen, Denmark.
Mr P.East, Department of Animal Science, University of New England, Armidale, NSW.
Professor D.A.Haydon, Physiological Laboratory, University of Cambridge, UK.
Professor Kwok Moo Son, Director of Institute of Chemical and Metallurgical Engineering, Peking, People's Republic of China.
Mr S.O.Obaga, Kenya Bureau of Standards, Kenya.
Professor Kuo Chun-yen and Dr Wang Ai-kwo of the South China Institute of Botany, Canton, and Professor Qui Guoxiong, Institute of Plant Physiology, Shanghai, People's Republic of China.
Mr S.K.Njuguna, Director, National Horticultural Research Station, Thika, Kenya.
Professor J.H.Moy, University of Hawaii, USA.
Professor Kiyoe Itoe, Tokyo University of Arts and Sciences, Tokyo, Japan.
Professor D.F.Farkas, College of Human Resources, Department of Food Science and Human Nutrition, University of Delaware, Newark, Delaware, USA.
Mr T.S.Srinivasan, Central Leather Research Institute, Madras, India.
Dr Abd-el Rahman Khane, Executive Director, UNIDO.
Professor U.Haeverlin, Max Planck Institute, Heidelberg, West Germany.

Prof.Dr D.Eckert, Ministry of Youth, Family and Health, and Chairman of joint FAO/WHO Codex Alimentarius Commission; Prof.Dr P.Nehrig, and Dr A.Roth, Head of German Federal Chemical Inspection, FRG.
Members of the Food Industry Council of Australia.



Members of Food Industry Council of Australia inspecting pilot-scale CSIRO counter-current extractor during visit to FRL

Dr D.Southgate, ARC Food Institute, Norwich, UK.
Dr R.G.Buttery, USDA Western Regional Research Laboratory, Albany, Calif., USA.
Dr D.A.Forss, Invermay Agricultural Research Centre, Ministry of Agriculture and Fisheries, Dunedin, New Zealand.
Messrs G.Robertson and A.Anderson, Department of Food Technology, Massey University, Palmerston North, New Zealand.
Professor E.A.Bell, Department of Plant Sciences, King's College, University of London, UK.
Dr W.Horwitz, Deputy Associate Director, Bureau of Foods, US Food and Drug Administration, USA.
Dr J.W.Kesterson, Brown Machinery Co., Calif., USA.
Dr P.Russell Eggitt, Dalgety Spillers, UK.
Professor J.H.May, University of Hawaii, USA.
Dr M.P.Pulle, University of Peradeniya, Sri Lanka.
Mr L.D.Melton, Lecturer in Food Chemistry, University of Otago, Dunedin, New Zealand.
Professor D.A.Walker, Biology Department, Sheffield University and Director, ARC Unit on Photosynthesis, UK.
Dr A.W.Holmes, Director, British Food Manufacturing Industries Research Association, Chipping Campden, UK.
Professors C.Eriksson and K.Ostland, National Swedish Board for Technical Development, Stockholm, Sweden.
Mr Shum Siew Khoon, Chemical Process Technology Division, Singapore Polytechnic, Singapore.
Professor G.P.Legoshin, Soviet Agricultural Council.
Dr Sridhidhat Arporn, Adviser to Thai Minister for Commerce.
Professor Hugo Aebi, University of Berne, Switzerland.
Dr M.I.Gurr, Nutrition Department, National Institute for Research in Dairying, University of Reading, Shinfield, UK.

Dr T.Sone, Director, Snow Brand Technical Research Institute, Japan.
Delegates to UNESCO Regional Workshop on the Application of Microbial Physiology and Genetics to Industrial Processes.

Foreign aid activities

In August 1980, at the request of the Department of Primary Industry of Papua New Guinea, Dr A.K.Sharp (FRL) travelled between Lae, Rabaul and Australia monitoring experimental shipments of cocoa and coffee. Tests were made on the technique of in-container disinfestation with carbon dioxide and on means of preventing condensation on the cargo. In February 1981 Dr Sharp returned to Rabaul to fit monitoring equipment to containers destined for Hamburg, West Germany.

In March 1981, at the request of the Australian Development Assistance Bureau (ADAB), Department of Foreign Affairs, Dr A.G.Lane and Mrs K.H.Adams (FRL) took part in an ASEAN Workshop on Biogas Technology (Manila, Philippines) and follow-up Seminars in Malaysia and Indonesia. Dr Lane also took part in an UNESCO Regional Symposium/Workshop on Biotechnology in the Utilization of Renewable Resources, Malaysia.

As part of the ADAB Aid to Bhutan Project, staff at FRL contributed to the training of five Bhutanese in aspects of postharvest fruit and vegetable storage.

Bhutanese visitors being trained to assess tomato quality

As a follow-up to a series of Indo-Pacific Fisheries Council Workshops on Fish Technology and Marketing, Dr J.N.Olley (TFRU, FRL) collaborated with the Tropical Products Institute, Ministry of Overseas Development (UK), the University of Tasmania and the University of Tromsø (Norway) to produce a series of papers on fish silage, fish drying and storage, and the effects of temperature on the spoilage of tropical fish.

Work overseas

Many officers of the Division travelled overseas on duty during the year. The great majority were on official non-quota visits, for which all or most of the travel expenses are provided by other organizations. Brief details of countries visited and conferences attended are given below.

Dr J.H.B.Christian (Chief): Europe, UK (June-July 1980). Attended XIV General Meeting of International Commission on Microbiological Specifications for Foods (Stresa, Italy), World Congress on Foodborne Infections and Intoxications (West Berlin, FRG), XI International Symposium of the Committee on Food Microbiology and Hygiene (Aalborg, Denmark). USA (November 1980): Australian delegate at meeting of Codex Alimentarius Committee on Food Hygiene, and chairman of meeting of FAO/WHO Working Group on Microbiological Criteria for Foods (Washington DC).

Mr J.F.Kefford (Assistant Chief): Malaysia, Indonesia, Singapore, Spain (September-October 1980). Invited plenary speaker at International Symposium on Food Technology in Developing Countries (Kuala Lumpur, Malaysia); attended (in capacity as Secretary-General) meeting of Executive Committee of International Union of Food Science and Technology (Valencia, Spain), Symposium on The Role of Science and Technology in Social and Economic Development (Valencia, Spain), and International Symposium on Energy and the Food Industry (Madrid, Spain). New Zealand (November 1980): presented Opening Address at International Symposium of Food Product and Process Development in Pacific Countries (Auckland).

Dr D.J.Walker (Assistant Chief) and Dr W.R.Shorthose (MRL): Argentina, Chile (November 1980). Delivered lectures at Third National Symposium of Science and Technology, and conducted Courses in Meat Science and Meat Industry (Buenos Aires, Argentina).

Dr A.R.Johnson (Assistant Chief): Singapore, Malaysia, Thailand, India, Bhutan, UK, Europe, Indonesia, Philippines, Papua New Guinea (August-October 1980). Attended meeting of IUPAC Commission on Oils and Fats (Paris, France), the 3rd European Poultry Congress (Hamburg, FRG), and 3rd ASEAN Congress on Nutrition (Jakarta, Indonesia).

Mr L.L.Muller (Assistant Chief): USA (December 1980). Joint investigation with Australian Dairy Corporation of arrangements for the commercial development of the Cheese Base Project. USA, UK, Europe, Hong Kong and Japan (May-June 1981): Attended IDF/IUFoST-sponsored seminar 'Utilization of Dairy Ingredients in the Food Industry' (Luxemburg).

Mr L.L.Muller, Dr J.G.Zadow and Mr F.G.Kieseker (DRL): Singapore (October 1980). Participated in Seminar on Recombination of Milk and Milk Products, organized by the International Dairy Federation.

Dr D.Graham (FRL): UK, USA, Canada, Japan, South-East Asia, Taiwan (June 1979-July 1980). Spent nine months at Botany School, University of Cambridge, UK, and two months at Agricultural Research Council Weed Research Organization, Oxford, UK; visits to South-East Asia related to the ASEAN

Postharvest Project, for which staff of FRL were concerned with planning and implementation. People's Republic of China (September 1980): Member of Australian delegation, sponsored by the Australian Academy of Science and the Academia Sinica, which visited horticultural and postharvest research centres in Bejing (Peking), Manchuria, Shanghai and Guangzhou (Canton).

Dr D.G.Laing (FRL): Netherlands (July-August 1980). Attended 7th International Symposium on Olfaction and Taste (Leiden); worked for short time in olfaction laboratory of University of Utrecht.

Dr R.J.Pearce (DRL): USA (October 1979-August 1980). Attended American Chemical Society Symposium on Food Proteins (Houston, Texas) and the Gordon Research Conference (New Hampshire); worked on functionality of food ingredients and the properties of the soybean system at Department of Food Science and Nutrition, Ohio State University.

Mr H.M.Chua (MRL): USA, UK, Europe, Singapore (August-October 1980). Attended 'Interkama 80', an International Exhibition of Data Collection and Materials Handling Equipment (Dusseldorf, FRG); studied materials handling systems for the meat industry.

Mr B.L.Sutherland (DRL): USA, Europe, UK (August 1980). Attended 4th Biennial Cheese Industry Conference, Utah State University (USA).

Dr R.F.Thornton (MRL): Eire, UK, Europe, USA, New Zealand (June-September 1980). Attended 26th Meeting of European Meat Research Workers (Colorado Springs, USA).

Dr F.B.Whitfield (FRL): UK, Europe, Canary Islands (September-November 1980). Attended 12th IUPAC Symposium on the Chemistry of Natural Products (Tenerife, Canary Islands) and 8th Congress of Essential Oils (Cannes, France).

Mr R.F.Adams and Mr G.Ford (FRL): Malaysia (September-October 1980). Conducted Course on Instrumentation Techniques on Gas Chromatography and High-Performance Liquid Chromatography at the Malaysian Agricultural Research and Development Institute (Selangor).

Mr P.J.Rutledge (FRL): UK, Europe (April-October 1980). Worked at Campden Food Preservation Research Association, Chipping Campden (UK), as recipient of CSIRO Study Award.

Dr K.E.Murray (FRL): New Zealand (August 1980). Guest lecturer at joint Annual Conference of N.Z. Institute of Chemistry and N.Z. Biochemical Society (Palmerston North) and principal lecturer at Workshop on Gas Chromatography-Mass Spectrometry organized by the Australian and N.Z. Society for Mass Spectrometry immediately following the Conference.

Dr J.E.Algie (FRL): USA, Europe (August 1979-October 1980). Twelve months' collaborative research on heat resistance of bacterial spores (Michigan State University, USA).

Drs W.G.Murrell, A.D.Warth, B.A.Cornell, J.A.Lindsay and J.E.Algie (FRL): USA (October 1980). Attended, under the auspices of the US/Australia Science Agreement, the 8th International Spore Conference (Woods Hole, Mass.) and participated in a Workshop on Basic Mechanisms of Bacterial Spores (University of Massachusetts, Amherst). Dr W.G. Murrell subsequently spent three months conducting collaborative research on spores at the Brookhaven National Laboratories, N.Y.

Mr H.H.N.Panhuber (FRL): Europe (December 1979-November 1980). Australian-French Government Scholarship for approximately eight months at Electrophysiology Department, Université Claude Bernard, Lyon (France); attended 7th International Symposium on Olfaction and Taste (Leiden, Netherlands).

Mr H.A.Bremner (FRL): USA (November-December 1980). Attended Third National Technical Seminar on Mechanical Recovery and Utilization of Fish (Raleigh, North Carolina).

Dr L.R.Fisher (FRL): UK, Europe, Canada, USA (April 1980-January 1981). Spent eight months at Physiology Department, University of Cambridge (UK), and one month in the Departments of Physical Chemistry and Colloid Science, University of Bristol (UK).

Dr R.L.Hood (FRL): USA (July 1980-July 1981). Collaborative research in Nutritional Physiology Laboratory, Department of Animal Science, Iowa State University, having been named Distinguished Foreign Scholar 1980/81 by the World Food Institute of that University.

Dr R.R.Hull (DRL): Indonesia (February 1981). Attended the Eighth Conference of the Association for Science Cooperation in Asia (ASCA) 'Traditional Food Fermentation as Industrial Resources in ASCA Countries' sponsored by the Indonesian Institute of Sciences (LIPI).

Mr G.R.Chaplin (FRL): USA, UK, Europe, Israel, India, Sri Lanka, Thailand, Singapore, Taiwan, Hong Kong, Philippines (February-June 1981). Studied aspects of postharvest handling, storage, research and marketing of tropical fruits (recipient of CSIRO Study Award 1980).

Dr D.J.Morton (MRL): UK, USA, Europe (February-September 1981). Collaborative research at Federal Research Centre of Agriculture, Braunschweig Volkenrode (FAL) and the Institute of Animal Husbandry, Mariensee, West Germany.

Dr R.E.Timms (DRL): Malaysia (May-June 1981). Collaborative research into crystallization of palm oil at Palm Oil Research Institute of Malaysia (PORIM); presented paper at 'Palm Oil Technology in the Eighties' Conference (Kuala Lumpur).

Mr R.G.Hamilton (MRL): New Zealand (November 1980). Attended International Symposium of Food Product and Process Development in Pacific Countries (Auckland).

Visits overseas

In the course of private visits overseas, the following members of staff returned to duty for short periods for official purposes:

Dr G.R.Jago (DRL) visited research laboratories in the USA and attended the 4th Biennial Cheese Conference at Utah State University.

Dr K.E.Murray (FRL) worked for two weeks on collaborative studies in the field desorption mass spectroscopy of lipids, at the Institute of Physical Chemistry, University of Bonn, West Germany, and visited research centres in Germany and France.

Dr A.K.Sharp (FRL) presented papers at the IIR Conferences 'Developments in Temperature Controlled Land Transport' (Prague, Czechoslovakia, March-April 1981) and 'Controlled Atmospheres Aboard Ships' (London, UK, May 1981) and visited research centres in UK and Eire.

Dr R.A.Leppik (MRL) presented a paper at the VIth International Fermentation Symposium, London, Ontario, Canada.

Mr R.D.Lipscomb (FRL) visited research institutes in the UK.

Mr J.D.Mellor (FRL) took part in the EEC COST 90 meeting on the thermophysical properties of foods, Karlsruhe, West Germany, and visited organizations concerned with data banking.

Dr G.W.Jameson (DRL) attended a Management Committee meeting and had discussions at Schrieber Foods Inc., Wisconsin, USA, regarding the Cheese Base Project.

Liaison and extension

Two schools were held at DRL on the theory and operation of the DRL pilot-scale UHT plant. These schools provided the information necessary for the operation of this unit by technical staff from companies with interests in UHT processing so that they could undertake their own product development programs.

A two-day industry meeting on factory-derived starters was held at DRL. It was attended by representatives from 14 manufacturers of commercial cheese and cultured milk products and by representatives of the Australian Dairy Corporation.

Members of DRL staff, together with members of the Victorian Division of the Australian Society of Dairy Technology, presented a two-day seminar on all aspects of UHT processing, aimed at both the research and factory operative level.

Close liaison was maintained with the Technical Services Group of the Australian Dairy Corporation. Two members of the Group are based at DRL, as well as a technical officer of Asia Dairy Industries Ltd.

Staff of DRL took part in the Australian Dairy Food Fair, a special event staged for retail trade and food service executives.

DRL's Stand at the Australian Dairy Food Fair

Staff of the TFRU (FRL) have collaborated with the World Health Organization in testing a number of liquid crystal thermometers, freezer thermometers, freeze watch ampoules and time/temperature indicators which, though designed for shipping of vaccines, could have application in the food cold chain.

TFRU participated in a Workshop on fish handling and quality control held in Darwin, sponsored by the Department of Primary Industry. The Unit also assisted in a Fisheries Officers Training Course held in Hobart, Tasmania, under the joint auspices of the Australian Maritime College and the Department of Primary Industry.

FRL cooperated with the Australian Citrus Growers' Association, Australian Citrus Processors' Association and the NSW Department of Agriculture in a project to improve processed Australian grapefruit juice.

In October 1980 FRL cooperated with the Working Party of the Entomology Committee of the Standing Committee on Agriculture in holding a seminar on 'In-container disinfestation with carbon dioxide generated from dry ice'. Concurrently, a container test facility, financed partly from a contribution from the Australian Chamber of Shipping, was opened for inspection.

In November 1980, a Workshop on methane gas production from fruit and vegetable factory waste solids was held at Leeton, NSW, using the demonstration digester jointly constructed by the Divisions of Food Research and Irrigation Research and Letona Foods Co-op Ltd.

Mr G.J.Williams, of Howden Refrigeration Pty Ltd continued collaborative work using the counter-current extractor at FRL. Facilities were also made available for Dr Robert M. Wechsler, Ultrapore, to work with CSIRO staff with a view

to developing porous films effective in scavenging oxygen from food packages and the like.

FRL maintained close liaison and extension with the following:

- Prawn investigations -
  NSW Department of Fisheries
  Queensland Department of Fisheries
  Western Australian Department of Fisheries
  Sydney Fish Markets

- Passionfruit investigations -
  NSW Department of Agriculture
  Queensland Department of Primary Industries, Redlands Horticultural Research Station

MRL conducted specialist courses for the food industry, including the following:

- School for Meat Industry Supervisors and Production Staff (Townsville, November 1980)

- Meat Quality Control Workshop (Richmond, NSW, February 1981) - organized jointly by CSIRO Division of Food Research and the School of Food Sciences, Hawkesbury Agricultural College

- Food Hygiene - a Training Package for Manufacturing Staff (MRL, Cannon Hill, Qld, May 1981) - TV training program.

Messrs P.M.Husband and B.Cain (MRL) visited the Broome abattoir (Western Australia) in May 1981 to help install and commission experimental equipment.

Staff attended and presented papers at many conferences in Australia throughout the year.

Books published

The following book was published:

Postharvest: An Introduction to the Physiology and Handling of Fruit and Vegetables. R.B.H.Wills, T.H.Lee, D.Graham, W.B.McGlasson and E.G.Hall. (Drs Graham and McGlasson are currently members of the Plant Physiology Group at FRL, and Mr E.G.Hall was leader of the Fruit and Vegetable Storage Section at FRL before his retirement).

FOOD RESEARCH LABORATORY

The Food Research Laboratory (FRL) has its main laboratory at North Ryde, NSW, with some of its Plant Physiology Group located at Macquarie University, a few kilometres from the main laboratory. FRL includes the Tasmanian Food Research Unit (Hobart), which is responsible for the major part of the Division's seafood investigations. FRL is jointly responsible, with the NSW Department of Agriculture, for the Gosford Horticultural Postharvest Laboratory (Gosford, NSW) which investigates postharvest wastage of fruits and vegetables and insect disinfestation of fruits. FRL conducts the Division's fruit and vegetable research and is also concerned with poultry and eggs and some aspects of the processing of meats. In addition, FRL undertakes studies which have a general application to foods. These include work on packaging, transport, storage, refrigeration, physical and chemical composition, microbiological stability, safety, nutrition, flavour and off-flavour development and composition, and sensory evaluation.

FRL also maintains a Liaison Section which handles requests for information and advice from industry, other institutions and consumers.

The research program of FRL is organized into five broadly-based interdisciplinary Groups: Applied Food Science, Food Safety and Nutritional Quality of Food, Food Structure, Plant Physiology, and Chemical Bases of Food Acceptance. In recent years the increase in Appropriation funding has not kept pace with the inflation rate and this has resulted in a severe contraction in research resources for FRL. Those resources most affected have been staff positions funded from Appropriation sources.

Some amelioration has resulted from the receipt of funds from other sources but the random distribution of staff losses places the viability of some research programs in jeopardy.

This situation has necessitated an internal review of FRL's research programs. The aim is to ensure that only those projects are undertaken for which adequate resources exist, or which can be supported by redeployment of staff or funds. Inevitably this involves a contraction in the research program at FRL and the discontinuation of projects which, under less stringent economic circumstances, would be accorded high priority.

APPLIED FOOD SCIENCE

The research program of the Applied Food Science Group is designed to develop new processes, equipment, products and knowledge for use by the Australian food processing industry. The projects cover many aspects of the processing, packaging and transport of foods, and of food engineering. There is also work on the interaction of singlet oxygen with components of processed foods and on the disposal of

solid processing wastes by anaerobic fermentation. The biologically active materials phleomycin and bleomycin are being produced in pilot-scale fermentation processes for further study in other CSIRO laboratories. A new study of allergens in peanuts was started in collaboration with Macquarie University, CSIRO Wheat Research Unit, Roche Research Institute of Marine Pharmacology, and clinical investigators.

Many of the projects in the Applied Food Science Group arise directly from requests and inquiries from the Australian food processing industry and related bodies. Others are undertaken because they seem likely to meet the future needs of the industry. The staff of the Group has frequent contact with technical and managerial staff in the food industry and also with some of the regulatory bodies and teaching institutes. Due to its direct concern with such a diversity of external interests, the Applied Food Science Group maintains close collaboration with the Liaison Section of FRL.

Processing and engineering

Counter-current extraction

D.J.Casimir
J.N.Huntington
G.J.Williams[1]

An Australian patent entitled 'Screw Diffuser' was granted in July 1980 for counter-current extraction equipment designed at FRL. A licensing agreement has also been entered into with Howden Equipment Services Pty Limited for the manufacture and world-marketing of the equipment. Following successful trials during the 1980 apple season, a commercial unit with a throughput of 150 tonnes/day has been built and will start up in New Zealand in the 1981 apple season.

Trials have shown that counter-current extraction has potential application in the grape juice, citrus and wine industries and in the extraction of sugars from beet, cane, sweet sorghum, grape marc and other residues. The recovery of soluble proteins and flavourings is also possible from edible grade residues from the prawn, crayfish and fish industries.

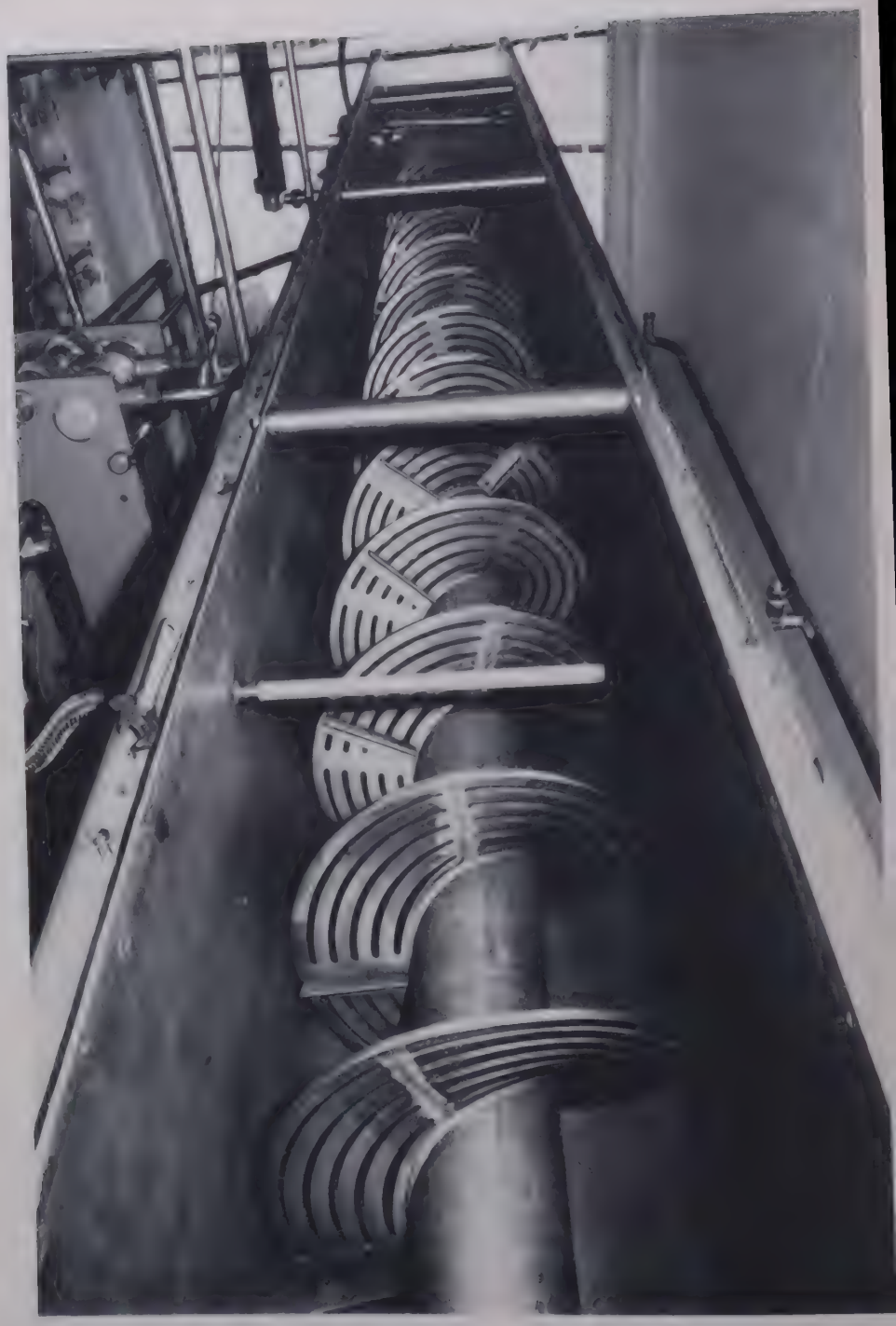
Further engineering and product application studies are planned under the three-year CSIRO-Howden licensing agreement.

Product studies

Improved drying and dressing oils for dried vine fruits

D.Barnett
Deborah E.Burton
A.C.Fogerty
D.McG.McBean

A detailed analysis was made of several commercial drying and dressing oils currently being used in Australia for the production of sultanas. The manufacture of fatty acid esters, which constitute the main component of drying oils, is being studied on a laboratory scale to find ways of reducing the costs of these components. The formulation of such laboratory products into drying oils with suitable emulsifying and drying properties is being investigated.



A pilot-scale counter-current extractor of capacity 0.5 tonne per hour

Storage life of dried sultanas

D.McG.McBean
R.L.McBride
K.C.Richardson

The experimental part of shelf-life studies on dried sultanas was completed and collection of data for statistical analysis was started. Sultanas of good initial quality may have a life of at least two years in almost any part of Australia and considerably more in the cooler areas. In contrast, lower grade fruit from a poor drying season may not maintain acceptable quality from one season to the next

Musty odour in sultanas

J.H.Last
D.McG.McBean
F.B.Whitfield

The quality of the 1980 sultana crop in Australia was excellent but a slight musty odour was detected in a small proportion of the fruit exported to Europe and Canada. Attempts are being made to identify the materials causing the off-odour and to find their source.

Apple processing

Helen J.Woods

Widespread extension services were provided to apple processors, government departments and industry committees.

A collaborative project with the Tasmanian Department of Agriculture to study the effects of fruit maturity and conditions of storage on juice quality is continuing.

Inter-laboratory survey of trace metal analysis

R.J.Coghlan
R.J.Steele

An inter-laboratory survey of trace metal analysis was started on behalf of the Department of Primary Industry *Ad hoc* Working Group on heavy metal contaminants in canned foods. The aim is to determine whether analyses of trace metals are sufficiently reliable in view of the limits which are being proposed for the contaminants. Cadmium, copper, iron, lead, tin and zinc were added to an apple purée stabilized with acetic acid. Homogeneity of the samples was checked by analysis before they were sent to government and food industry laboratories.

Food allergens

D.Barnett
R.W.Burley
M.E.H.Howden[2]

Immediate hypersensitivity reactions to legumes, particularly peanuts, are common and may be severe in some individuals. Peanut protein fractions were examined to determine which components are responsible for the IgE mediated reactions of sensitized patients. A number of allergenic fractions were obtained by classical, ion exchange and gel permeation techniques. However, affinity chromatography using glycoprotein specific lectins proved the most promising procedure. Structural characterization of some of these materials is proceeding.

The allergenic cross-reactivity between peanuts, other legumes and common foods is being surveyed by use of immunological techniques.

Waste utilization and disposal

Production of methane from cannery wastes

B.R.Crowley
J.N.Huntington
A.G.Lane

The small-scale, commercial anaerobic digester at the Letona Cooperative Cannery, Leeton, NSW, was operated for six months on pelletized orange peel. In all, 5100 kg of pellets were fed to the digester, and during one period of two months the loading rate was maintained at 70 kg/day. The gas yield from this stock was 0.465 m^3/kg, which agrees well with the results obtained earlier in the 3750-l digester at North Ryde.

After the successful completion of that trial, feeding of apple press cake from the production of apple juice commenced. A supplementary feed system was constructed to enable apple press cake to be fed to the digester. It consisted of a stainless steel hopper fitted with paddles to break up the press cake. The initial loading of 400 kg/day (3.5 kg dry matter/m^3/day) was soon raised to the maximum design loading of 500 kg/day (4.3 kg dry matter/m^3/day). In all, 26 789 kg of apple press cake were fed and 2218 m^3 of gas produced. The mean gas yield was 0.436 m^3/dry kg.

These extensive trials confirmed that cannery staff are able to handle all aspects of the operations including monitoring and maintenance of the digester. They also

showed that results obtained with laboratory digesters can be reproduced under industrial conditions.

Finally, the digester was fed waste from the canning of pears, peaches and apricots (8-10% solids). With a loading rate of 500 kg/day, 30-40 m^3 of gas were generated.

Toxicity of orange peel components in anaerobic digesters

B.R.Crowley
A.G.Lane

Orange peel, which is toxic to the anaerobic digestion process because of the presence of citrus oil, was successfully digested after removing the oil in a two-stage process involving a mechanical treatment followed by steam distillation. However, this method was found to be impractical for an industrial process.

Anaerobic glove bag for manipulating extremely anaerobic microorganisms

A machine recently marketed by the Brown International Company removes a higher proportion of oil from citrus peels than earlier machines. Laboratory trials showed that orange peel so treated could be digested at a loading of 3 kg dry matter/m^3/day; no symptoms of toxicity developed over a 7-week trial period at this loading.

Phleomycin and bleomycin production

A.G.Lane
Janice M.Myers

The potential of phleomycins and bleomycins as anti-cancer drugs is being evaluated in a project involving the Divisions of Food Research and Applied Organic Chemistry, and the Molecular and Cellular Biology Unit. Production of fermentation liquors in 10-l and 100-l batches is continuing, providing material for fractionations, analysis and biological testing.

Packaging

Singlet oxygen in polymer matrices

R.V.Holland
M.L.Rooney
R.A.Santangelo
A.J.Shorter

Polymer films containing light-activated dye sensitizers and singlet oxygen acceptor compounds are efficient oxygen scavengers. As these films are cheap and simply made, they have many possible applications in the food industry.

Further development and optimization of these materials may result in an increase in both the oxygen uptake rate and in the absorptive capacity of the films. Consequently, both the light absorption mechanisms and the basic diffusion chemistry are being studied to obtain fundamental knowledge of reactions in the polymer solid state.

Measurement of oxygen and moisture permeabilities

R.V.Holland
R.A.Santangelo

A simple technique for measuring oxygen permeability of packaging films (patent applied for) was devised. A singlet oxygen sensitive film acts as an efficient detector and is clamped to the test film in a small, specially designed cell. Permeability of the test film is measured rapidly and simply using a spectrophotometer.

A similar technique is being developed to measure water vapour transfer rates through test films. In this case, the detector consists of cobalt chloride dissolved in a cellulose film. The sensitivity of the film permits permeability measurements to be made in a few hours instead of many days by other methods.

Both of these techniques are suitable for use in quality control laboratories.

Photochemical scavenging of oxygen from enclosed systems

R.V.Holland
K.C.Richardson
M.L.Rooney
A.J.Shorter

A process was developed to remove residual oxygen from packages that have been flushed with inert gas. The basis of the process is the photosensitized reaction of oxygen with a scavenging compound dissolved in a polymer film. The technique appears to have the potential to remove oxygen from an air headspace in a transparent package without the need for evacuation or inert-gas flushing.

Sensitizing efficiency of food colours

I.Kraljic[3]
M.L.Rooney
A.J.Shorter

Some permitted food colours have been found to be bleached by photosensitizing dyes. The effect of illumination on mixtures of erythrosine, and sunset yellow or tartrazine is being studied to determine ways of preventing colour changes.

Sulphur dioxide isotherms in foods

D.Barnett
E.G.Davis
Phyllis M.Moy

Further work on the equilibrium between free sulphur dioxide in white wine and the concentration of headspace sulphur dioxide showed that the relation is strongly dependent on pH. Studies on the solubility of sulphur dioxide at low concentrations in water showed that the level of gaseous sulphur dioxide is related directly to the amount of molecular or undissociated sulphur dioxide in solution rather

than to free sulphur dioxide which includes dissociated bisulphite and sulphite ions. Tests on a range of liquid foods adjusted to various pH levels showed that molecular sulphur dioxide levels may be determined reliably by headspace analysis and that free sulphur dioxide contents may then be calculated from these data using the known dissociation constant for sulphurous acid and pH of the food concerned.

Aluminium corrosion

P.W.Board
R.J.Coghlan
R.J.Steele

A number of aluminium alloys to which a range of other selected metals were added were prepared in the laboratory. The effect of these added metals on corrosion rates in solutions at low pH was measured. While these accelerated corrosion rate measurements are reasonable indicators of performance, they do not accurately represent corrosion processes in aluminium alloy food containers. For example, the accelerated experiments produced uniform etching over the surface of the alloys, whereas localized pitting is the typical corrosion pattern in commercial food packs.

Tests to simulate food systems more closely are being evaluated. Special attention is being directed to those tests which may be useful to food manufacturers in quality control operations.

Thermophysical properties of foods

J.D.Mellor

A bibliography consisting of 500 references was researched and published.

Further data on enthalpy, specific heat, thermal conductivity and diffusivity of foods were collated and are being tabulated for publication.

Work is proceeding on smoothing part of the experimental data for equal intervals of temperature, and specific heat is being estimated from certain enthalpy data. This aims to ensure that the data are more amenable for the engineering and technological fields. A number of computer programs were devised to handle the estimations efficiently.

Food transport investigations

Disinfestation of freight containers using carbon dioxide

D.B.Drewitt-Smith
J.van Greve[4]
A.R.Irving
A.K.Sharp

The procedure developed by CSIRO for disinfesting produce carried in freight containers has been accepted for wheat and is being extended to other foodstuffs. Six containers of cocoa and coffee were treated with carbon dioxide in an experimental shipment between Papua New Guinea and Australia. Containers of sufficient gas-tightness were selected from those in commercial service. Carbon dioxide was added initially as dry ice pellets in some containers and as dry ice 'snow' in others. A continuing addition of carbon dioxide was provided in all containers from dry ice pellets enclosed in an insulated box. Satisfactory carbon dioxide levels were attained in all containers which met the gas-tightness standard, and a satisfactory kill of test insects was achieved. A prototype device to measure gas-tightness proved to be reliable and simple to use and is now being offered for commercial production.

Prevention of condensation in containers

D.B.Drewitt-Smith
J.van Greve[4]
A.K.Sharp

Condensation may occur in general-purpose (unrefrigerated) containers when relatively moist commodities are transported from a warm region to a cooler one. Cocoa and coffee are especially prone to condensation damage while being shipped from the tropical growing areas to the countries of processing, most of which are in temperate zones.

Following a successful trial of a prototype ventilated container during the winter of 1979, a second more comprehensive experimental shipment was run in August 1980. Three variants of ventilation opening were investigated, two containers being modified to each pattern. These were compared with standard general-purpose containers and 'open-sided' containers. Temperatures, water vapour levels and the presence of condensation on the interior surfaces were monitored during the journey. Light to moderate condensation occurred in both general-purpose and 'open-sided' containers but none occurred in any of the ventilated containers. From measurements made during the voyage it appears that condensation is prevented in ventilated containers not only by the venting of moist air, but also by more rapid cooling of the cargo during the initial part of the voyage; thus there is less chance of condensation on arrival in the colder regions.

Another experimental shipment into the more rigorous northern European winter, to compare the most promising prototype container with a British one, is being undertaken.

Transport of onions ventilated with ambient air

D.B.Drewitt-Smith
A.R.Irving
A.K.Sharp

Onions can be stored for long periods under refrigeration, but, unlike many other fresh products, they can also be stored at ambient temperatures provided they are adequately ventilated at all times. Onions have always been shipped to Pacific ports unrefrigerated in ventilated holds, stowed in net bags on pallets or in open-sided containers, but they have usually been carried to more distant ports in refrigerated containers. Shipments in ventilated below-deck space on roll-on, roll-off ships are now being monitored to determine why onions carried in this way sometimes outturn in poor condition. The feasibility of fitting forced ventilation to unrefrigerated containers is being examined for use on fully containerized ships.

Transport and storage of bananas

B.B.Beattie[5]
D.B.Drewitt-Smith
A.R.Irving

The Banana Industry is re-assessing its packaging, handling and ripening system because of increasing costs. New cartons (27-1 and 36-1) suitable for forced-air cooling have been designed so they can be stacked in columns in a closed stow on pallets. In addition, some ripening rooms have been modified by installing forced-air circulation systems.

It was shown that a more uniform temperature is maintained in bananas in both types of new cartons in the modified ripening rooms compared with existing cartons (B13) in a conventional room. There were no significant differences in the temperatures of bananas in the three different cartons transported in louvred rail vans during temperate weather conditions. Further investigations will be carried out during transport in hot weather (above 30°C) in louvred vans and RACE (Railways of Australia Container Express) containers.

Air circulation in refrigerated ISO containers

D.B.Drewitt-Smith
A.R.Irving

Even distribution and sufficiently high air flow are necessary to ensure a narrow temperature range in produce shipped in refrigerated containers. The flow rate in some containers was found to be below that specified by the manufacturers.

The flow rates in refrigerated containers from different manufacturers are being measured using a specially designed flow rig. The results are being compared with those given by other methods of measuring air flow rate such as vane anemometers.

Container test facility

D.B.Drewitt-Smith
A.R.Irving
A.K.Sharp

A facility for testing 6.1-m freight containers was commissioned at FRL. Small refrigerated vehicles may also be tested in the unit. A container mounted on a road trailer or on heavy duty castors can be subjected to temperatures in the range 0°–50°C in the test room. Data-logging equipment is being developed that will allow the facility to be used to perform thermal testing to international standards and will also permit the simulation of land and sea voyages.

Official opening of container test facility at FRL

CHEMICAL BASES OF FOOD ACCEPTANCE

This Group seeks a better understanding of the role of food composition in determining consumer acceptance of foods. There are five sub-programs:

- Volatile flavours.- Identification, principally by gas chromatography, mass and nuclear magnetic resonance (n.m.r.) spectrometry and chemical microreactions, of volatile components responsible for the desirable and undesirable flavours of foods, with particular attention to the origin of flavour changes.

- Non-volatile food components.- Chemical studies related to food components which affect consumer acceptance through physiological and nutritional effects or through taste and appearance.

- Mass spectrometry.- The application of advanced techniques in mass spectrometry for the identification, analysis and determination of the structure of food components that are being studied in the Division.

- Sensory evaluation.- Investigations into the physiological and psychological mechanisms involved in responses to the flavour (taste and odour) components of foods. The ultimate goal is the development of standard objective methods for measuring these responses.

- Quality improvement.- The development of procedures to improve consumer acceptance of foods by modifying their chemical composition.

Volatile flavours

Crustacean flavours

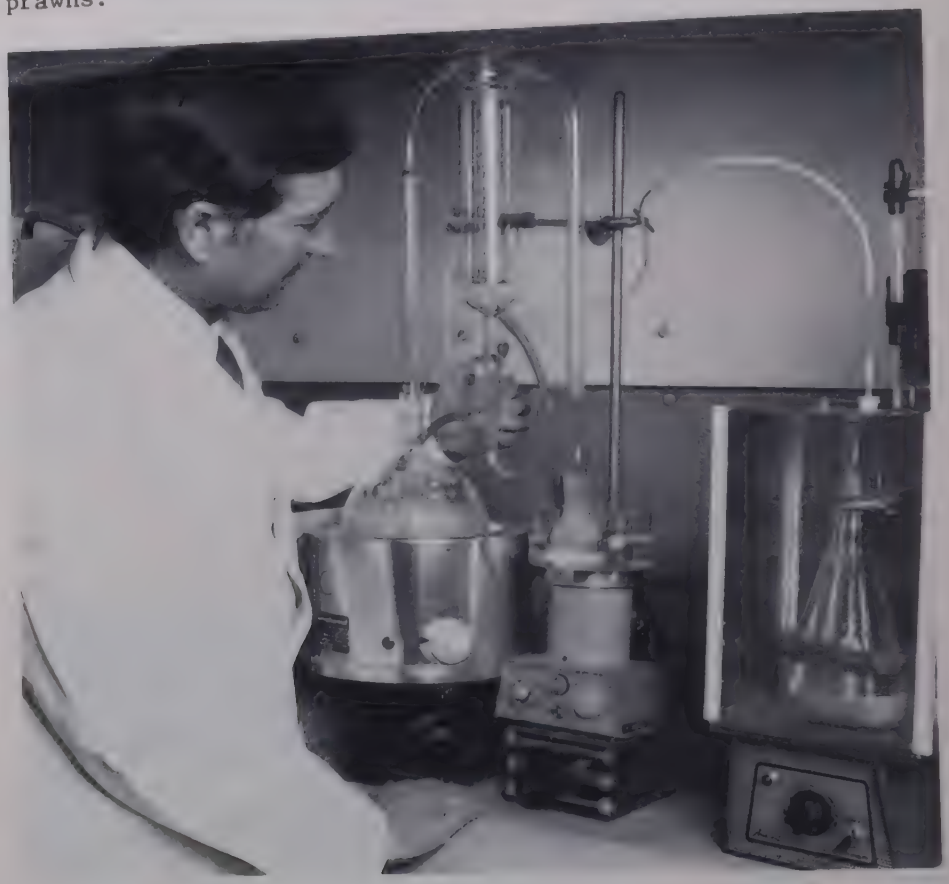
P.A.Bannister
Diana J.Freeman
B.H.Kennett
F.B.Whitfield

The flesh of the sand-lobster, *Abacus peronii*, possesses an intensely disagreeable off-flavour. Such flesh was shown to contain bis-(methylthio)-methane, the compound responsible for the garlic off-flavour sometimes noted in the royal red prawn, *Hymenopereaus sibogae*. The off-flavour is much more intense in the sand-lobster than in the royal red prawn since the two species contain 10-20 and 1-4 $\mu g\ kg^{-1}$ of the compound, respectively.

Oct-1-en-3-ol and *cis*-octa-1,5-dien-3-ol, compounds associated with the mushroom-metallic off-flavour of prawns, were also isolated from off-flavoured sand-lobsters but in concentrations much lower (14 and 11 $\mu g\ kg^{-1}$ respectively) than those in off-flavoured prawn samples (40 and 49 $\mu g\ kg^{-1}$ respectively.

A batch of royal red prawns, condemned for their offensive odour, were found to contain indole (19 $\mu g\ kg^{-1}$) and dimethyl trisulphide (4 $\mu g\ kg^{-1}$); these compounds have, respectively, intense faecal and offensive onion odours. Indole is a known by-product of microbial spoilage of crustacean flesh and the trisulphide may also be produced by

microbial activity as it is absent from freshly caught prawns.



Isolating volatile compounds from off-flavoured prawns

Off-flavours in processed foods

P.A.Bannister
J.H.Last
G.Stanley
F.B.Whitfield

Several requests were received from the food industry to determine the causes of off-flavours in certain processed foods. Examination of solvent extracts of these foods by gas chromatography and mass spectrometry led to the recognition of possible contributors to the off-flavours. Three compounds with mouldy aromas were detected in dried fruit with a musty off-flavour and were tentatively identified as chloroanisoles; chlorophenols were indicated as responsible for a medicinal off-flavour in canned fruit; and an unidentifiable compound with an intense mouldy aroma was detected in chilled meat with an earthy-musty off-flavour. Studies were commenced to determine the origin of these compounds.

Passionfruit flavours

P.A.Bannister
B.H.Kennett
J.H.Last
F.B.Whitfield

The original purple passionfruit, *Passiflora edulis* Sims, has been replaced in commercial Australian plantings by four *P.edulis* x *P.flavicarpa* hybrids which are more rugged and crop better than the purple parent. However, processors have recently complained that the juices from these hybrids lack the characteristic flavour associated with *P.edulis*. Examination of the volatiles in summer and winter fruit from northern New South Wales by gas chromatography and mass spectrometry has now shown significant quantitative, though not qualitative, differences between all four hybrids and the parent fruit. The ionone-related compounds (β-ionone, edulan I and the megastigma-4,6,8-trienes) and the ethyl esters of C_8 acids with one and two double bonds were in much higher concentration in *P.edulis* and, since they are regarded as the most important components of passionfruit flavour, the poorer flavour of the hybrids can be

thus explained. In addition, two new volatile passionfruit components have been identified: the dia-stereoisomeric *erythro*- and *threo*-2-(3-hydroxybutyl)-butanoate. Both possess green, fruity aromas and are present in reduced concentration in the hybrids.

Non-volatile food components

Amines

D.Gallimore
D.L.Ingles
C.R.Tindale

Studies are continuing on food amines implicated in dietary migraine and other physiological disorders. New high-pressure liquid chromatography techniques have been devised for analysis of the fluorescamine derivatives of primary amines. The derivatives are prepared as usual but are then converted into their free acid forms which are extracted into chloroform and chromatographed directly. Provided that acidic solvents are used in the chromatographic separation, resolution of the amines is much improved, and the identity of the peaks in the effluent can be directly checked by field desorption-mass spectrometry (f.d.m.s.) after minimal clean-up.

Mass spectrometry

Analysis of amines

K.E.Murray
K.J.Shaw

A technique developed for the screening of amines in foods by f.d.m.s. of their fluorescamine derivatives was applied to the examination of amines in the faeces of children with gastro-intestinal infections. In conjunction with the Royal Alexandra Hospital for Children, 50 specimens of diarrhetic stools were examined from children suffering a variety of bacterial and viral infections. There were, in general, larger amounts of tyramine, β-phenylethylamine, and acyl cadaverines in these specimens than in faeces from normal children, but no fixed patterns of amines were evident corresponding to the various types of infections. The technique has since been augmented by the f.d.m.s. of the dansyl derivatives of amines, both in mixtures and after separation by thin layer chromatography. The combined techniques are being used for a more comprehensive study of the amines related to intestinal flora, particularly in children with food-related disorders. In collaborative studies with the Food Safety and Nutritional Group, tyramine, together with *p*-cresol and phenol, was identified in the colonic fluid taken from a 3-year-old boy who had died of chronic botulism; the results indicated that these potentially toxic compounds were present in substantial amounts.

Structural identification by f.d.m.s.

K.E.Murray
K.J.Shaw

The Varian mass spectrometer has played an active supporting role as a tool for structural analysis in several Division of Food Research research projects, namely studies of photoxidation products from bacterial spores, soya bean saponins, and phospholipids at FRL and of products of microbial transformation of bile acids at MRL. Many requests have also been received from other laboratories for assistance in the structural determination of physiologically important compounds, particularly those too unstable to be readily examined by other methods. Among these were the

corynetoxins, a family of toxins produced by bacterial infection of the seedheads of annual ryegrass, which are being studied by the Division of Animal Health. Another compound studied of considerable economic importance was agropine, which is produced in crown gall tumours of plants following infection with certain strains of *Agrobacterium tumefasciens*. In collaborative studies with the Waite Agricultural Research Institute and the Station de Genetique et d'Amelioration des Plantes CNRA at Versailles, France, the recently published structure for agropine was shown to be incorrect and the correct structure has been established.

Recording analogue data

E.J.Bourn
G.Stanley

A new tape recording and replay unit, developed from the successful SIMTRAD devices for recording mass spectral and gas chromatographic data, was constructed for the Plant Physiology Group. The new device has a wider band width and a higher output level than previous units and carries an event-marking facility. It has been successfully used to acquire fluorescence data which was later replayed into the Division's PDP 15 computer.

Sensory evaluation

Anatomical and behavioural studies of odour recognition

D.G.Laing
H.H.N.Panhuber
Elizabeth Pittman
Katherine Spitzer

Continuous exposure of young rats to a single odorant for one to two months results in morphological changes in specific mitral cells in the olfactory bulb. To quantify these changes, a computer-assisted morphometric technique is being used to establish the patterns of normal and altered cells on exposure to different odours, with the premise that each pattern represents a spatial code by which the brain recognizes that particular odour. Statistical methods recently developed to verify these patterns showed considerable variation in the size of mitral cells in normal olfactory bulbs. Rigid analyses will therefore be necessary when comparing changes in animals reared in normal and odorized environments.

A collaborative study with workers at the Australian National University has commenced aimed at determining the genesis of the morphological changes occurring during prolonged odour exposure. Neurotransmitters and their precursor enzymes are being measured in the olfactory bulbs of rats reared in an environment of rat odours or deodorized air. Components involved in both afferent and efferent pathways are under study, the latter because changes in their concentration may indicate significant morphological changes at higher olfactory centres. However, difficulties encountered during measurement of carnosine (the presumed major neurotransmitter from the nose to the bulb) indicate that a more sensitive analytical technique is required.

Quantification of human responses to odours

D.G.Laing

Quantitative measurements of human responses to odours have been hindered by the absence of a standard instrument for presenting odours and of standard instructions to subjects for odour sampling. As a first step toward standardization, natural sniffing techniques of over 20 subjects were characterized during odour threshold and intensity tests. Results showed clearly that many instruments used in olfaction studies do not cover the wide range of sniff rates and volumes exhibited by humans. However, these natural sniffing

techniques may not provide optimum odour perception necessary for quantitative measurements. Current studies indicate that a single sniff provides the same information as 3, 5 and 7 sniffs, that the interval between sniffs in the same sampling is unimportant, but that weak and strong sniffs provide different information.

Perception of odour mixtures

D.G.Laing
Mary E.Willcox[6]

Food odours are usually perceived as mixtures, since a food rarely contains a single component characteristic of its overall aroma. However, little is known about how humans perceive odour mixtures and how odours interact to produce the wide variety of aromas perceived even from the same food. It is therefore difficult to estimate the relative importance of the many odorants present in a food. For example, the rancid odour accompanying the oxidation of fats is characterized by the formation of many components of which aliphatic aldehydes are presumed the most offensive. In collaboration with the Swedish Food Institute, the odour properties of mixtures of two such aldehydes, *trans*-hex-2-enal and *trans*-dec-2-enal, were investigated.

By using a wide variety of statistical techniques, including a multi-dimensional scaling method, it was found that low concentrations of the hexenal increase the perceived intensity of the decenal but that the perceived intensity of the hexenal was decreased by low concentration of the decenal. Significantly, both odour quality profiles and odour intensity data demonstrated that the perception of either aldehyde in a mixture was dependent on its intensity: only the component with the highest intensity was perceived, even when both were present in high concentrations. When present at equal odour intensities, both aldehydes were perceived and there was no blending to form a new odour.

Psychophysics of taste: sensory measurements

A.Kuskis
R.L.McBride

A systematic re-evaluation of fact and theory in psychophysics showed that the commonly accepted magnitude scales of sensation, obtained directly by ratio scaling techniques (e.g. magnitude estimation), are invalid because of non-linearity in the perceived number continuum. Instead, valid psychophysical scales could be based upon two underlying premises: the Weber function and Fechner's original proposition that just noticeable differences (JNDs) are subjectively equal. Together, these two premises specify the indirectly derived, and obsolete, JND scale. However, two predictions follow from this revised theoretical model: valid psychophysical scales should be obtained by category rating, and all such scales should be congruent with their corresponding JND scales. The latter prediction has been confirmed empirically for stimuli representative of the four basic tastes: sweet (sucrose), acid (citric acid), salty (sodium chloride) and bitter (caffeine).

Acceptability of prunes

Christabel Craker
A.Kuskis
D.McG.McBean
R.L.McBride

A panel of 24 experienced assessors scored the appearance, flavour, texture and acceptability of moist-packed prunes which had been harvested at four stages of maturity. Overall, the more mature prunes were very significantly better in appearance, and significantly better in flavour and acceptability, but there was no effect of maturity on scores for texture.

Quality improvement

Horticultural variables and grapefruit juice quality

B.V.Chandler
Maxine Collins
R.L.Johnson

Examination of 28 grapefruit juices processed from representative crops grown in four major citrus areas and sampled over the 1980 season showed little difference in quality within districts. However, very considerable differences were noted between districts in total soluble solids (TSS) content and TSS:acid ratio but not in acid content, and in limonin but not in naringin contents. There were also differences between districts (but not within districts) in mean fruit weight and mean juice content, but not in juice yield. Only one of the juices would have passed the Florida Department of Citrus standards for Grade A grapefruit juice and only a few of the juices were rated acceptable by a panel of experienced grapefruit juice drinkers. Very significant linear correlations were established between panel scores for sugar-acid balance, grapefruit flavour and general acceptability and the TSS:acid ratio, and between panel score for bitterness and the limonin but not the naringin contents. Consideration of these results suggested that acceptable juices could be prepared from crops grown in each of the districts by delaying the pick until a date specified for that district and adding up to 4% (w/w) sucrose to the juice; such addition is allowed by current Australian food regulations without label declaration.

Adsorptive processes applied to grapefruit juice

Maxine Collins
R.L.Johnson

Twelve commercially available and relatively inexpensive polymers have now been tested for their efficiency in reducing bitterness and acidity in grapefruit juice; all the polymers had either been approved for use with foods or were chemically similar to approved materials. The polymers differed in their adsorptive capacity, with maximum removals of about 85% limonin, 70% naringin and 55% titratable acidity. By choosing the appropriate adsorbent, various combinations of these components could be removed, but no single polymer was a strong adsorbent of all three. However, by using two of the polymers in consecutive treatments excessive bitterness and acidity could be removed from juices containing up to 2 g naringin and 36 mg limonin per litre and with a TSS:acid ratio of more than 6. Such treatments, followed by the addition of 2-3% (w/w) sucrose, would have produced products meeting Florida Department of Citrus specifications for Grade A sweetened juice from all but one of the 28 juices mentioned in the previous paragraph.

Adsorptive processes using cellulose acetate

R.L.Johnson

The operation of the model cellulose acetate gel bead column used for de-bittering Navel orange juice was examined over a number of treatment and reactivation cycles. The processes involved could be fitted to standard mathematical equations for extraction processes, adsorption corresponding to liquid-solid extractions and reactivation to solid-liquid extractions. These equations were used to calculate the conditions for the steady state operation of the column that would allow removal of 50-70% of limonin from juice during passage through a continuous processing line.

Contactor containing adsorbent resin for adsorbing acid and bitter principles from citrus juices

FOOD SAFETY AND NUTRITIONAL QUALITY

The safety and quality of foods are affected by many changes that may occur during production and handling of raw materials, and throughout the ensuing processing, storage, marketing and treatment in the home. The Group's research role concerns any of these areas where knowledge is inadequate. Two main areas are presently under study.

- Microbial status and safety of food.- Most of the projects in this area concern the bacterial, viral and fungal status of foods and the physiological factors that

determine the ability of the organisms to survive, grow and produce toxins under various processing and storage conditions.

The interaction of natural and added food components with the microbial population of the intestine is being studied to assess whether these may adversely affect the host as a result of disturbances to the gut microflora or by causing the microflora to produce harmful metabolic products.

In recent years, projects have been initiated to devise methods for controlling salmonellae in broiler chickens.

The projects on bacterial spores aim to explain the physiochemical and physiological phenomena by which bacterial spores achieve their extraordinary resistance to destruction. The program is concentrating on non-destructive biophysical probes to define the biophysical state in the protoplast ('core') of the spore and thereby identify the cellular and molecular mechanisms that confer resistance. It is hoped that an understanding of these may lead to better methods of killing spores.

- Nutritional status and quality.- Food quality is a complex integration of nutrient content, flavour, texture and colour and may be influenced by many changes during production, and between production and consumption. Some of these changes are desirable, others undesirable. Research projects involve fats and oils, fat metabolism, and fat deposition in broiler chickens.

  As well as a nutritional role, food components may affect health by their physiological activity. Further, some important nutritional constituents may not be completely available because they are chemically or physically bound or degraded chemically or enzymically during digestion. These effects may lead to misleading nutritional food composition data based on *in vitro* analyses. Current research projects are concerned with the conjugated fatty acid content of dietary fat, and with the bioavailability and nutritional significance of biotin.

MICROBIAL STATUS AND SAFETY OF FOODS

Clostridium botulinum

Infant botulism

W.G.Murrell
Betty J.Stewart

The incidence in soil samples of *Clostridium botulinum* type A, the causative bacterium of infant botulism on a NSW pastoral property, was surveyed. Five of seven samples in the house area contained *C.botulinum* type A spores whereas only 2 of 25 samples from elsewhere on the property were positive.

In a second series of samples (172) the bacteria appeared to be concentrated to the north-east of the house for 300 m, to the south for 100 m and to the west for 200 m. The bacteria occurred to a depth of 18 cm and numbered from 0.12 to 37 per g. This apparent concentration may have resulted from growth in carrion with ensuing soil contamination.

In the case of an affected infant from a suburban home, *C. botulinum* type A and B were isolated from faecal samples and garden soil, both types from one soil sample. Although only type B toxin was detected in the faeces, inadequate sample size prevented toxin typing in some samples.

Infant botulism in mice

R.F.Adams
Patricia L.Conway

Studies were undertaken to identify ecological determinants that would affect the colonization of *C.botulinum* in the gut. Using the infant mouse as the animal model it was found that toxin production from *C.botulinum* type A was more rapid in the gut than *in vitro*. Toxin at sub-lethal levels slowed transit through the gut. The early production of toxin and its effect on gut transit time could be ecologically advantageous to the bacteria because of the greater opportunity for colonization.

Ascorbic acid present in the gut concurrently with spores prevented the appearance of toxin in the colon. At increasing times after ceasing ascorbic acid dosage, active toxin was produced in increasing quantities until the amount was greater than in control animals.

Animal botulism

W.G.Murrell
Betty J.Stewart

Samples from suspected botulism in cats, horses and dogs were examined. Type C botulism was confirmed in one dog, toxin being demonstrated in the serum and faeces, and the bacteria were isolated from the faeces.

Viruses in foods

Oysters

G.R.Davey[7]
M.J.Eyles
Helen M.Wane

A survey was commenced to obtain a better understanding of the microbial ecology of oyster growing areas and oyster purification processes. Oysters, water and sediments at selected sites are being monitored bacteriologically, virologically and physicochemically. Oysters from these sites, purified commercially, are being tested bacteriologically and virologically on a regular basis. Laboratory scale studies on the purification of oysters, contaminated with realistic concentrations of attenuated poliovirus type 1 and *Escherichia coli*, are in progress. Both poliovirus and *E.coli* were eliminated from oysters within the purification times used commercially provided that environmental conditions in the purification apparatus were carefully controlled. Present bacteriological standards for purified oysters may be inappropriate in some respects.

Mycology

Physiology of xerophilic fungi

Ailsa D.Hocking
J.I.Pitt

This new project aims to investigate some of the physiological mechanisms that enable fungi to grow at low water activities. The internal solutes accumulated by five fungi with differing water relations in response to high concentrations of NaCl, glucose/fructose and sorbitol in the

growth media are being studied. Preliminary results indicate that glycerol is the major osmoregulatory solute in the xerophilic fungi studied. Other polyols such as arabitol, mannitol and erythritol are present in lower concentrations.

Aflatoxin in Australian peanuts

Dianne R.Glenn
Ailsa D.Hocking
J.I.Pitt

Analysis of peanut and soil samples obtained during the 1980 harvest season continued into this year. Much of the aflatoxin present in dried peanuts was formed before the peanuts were harvested, although the subsequent 6 to 14 days drying period also provided ample opportunity for aflatoxin synthesis. Unlike virgin forest soils, soils that have been used for peanut growing contain a high level of *Aspergillus flavus*, and the 1980 drought provided conditions resulting in a high level of invasion of the peanuts by *A. flavus* in that season. Further extensive sampling is under way in the 1981 season. Storage trials have been commenced to determine the influence of temperature and water activity on the production of aflatoxin by relatively dry peanuts in storage.

Ochratoxin A

J.I.Pitt
N.F.Tobin
A.D.Warth

Difficulties were experienced in obtaining significant ochratoxin A production by *Penicillium viridicatum* in liquid synthetic media. Studies on the production of ochratoxin A by this fungus on wheat, equilibrated to various water activities, have commenced.

Heat resistant fungi

Ailsa D.Hocking
J.I.Pitt

Fungal spoilage of commercially prepared pasteurized fruit juices and baby foods was traced to the presence of heat resistant fungal spores, probably present as contaminants in passionfruit juice. The fungi identified most frequently were *Byssochlamys fulva*, *Talaromyces bacillisporus* and *Neosartorya fischeri*. Testing procedures were devised to assist the food industry in monitoring the presence of heat resistant mould spores in raw materials.

Gut microflora

Effect of food components

R.F.Adams
Patricia L.Conway

The project aim is to study, as an ecological system, the interrelations of food components, the gut microflora and the host and to assess the effect of any disturbances to system on the health of the host.

Preliminary studies of heavy metal tolerance in the human gut microflora have resulted in the isolation of five bacteria and one yeast that are metal tolerant. The bacterial isolates were *Escherichia coli* (2 strains), *Enterobacter cloacae*, *Streptococcus faecium* and *S.faecalis*. Samples from five subjects, aged from 1 to 70 y, showed no correlation of bacterial type with age.

Studies with rodents were initiated to determine if the combinations of high concentrations of sugars in acid solution (to simulate soft drink base) altered the microflora. Changes in metabolism of the microflora and in surface associated microorganisms of the squamous stomach tissue, the ileum and the caecum were noted. Similar experiments, using drinking water supplemented with 12% ethanol, gave preliminary data which indicated that the major effect was on those microorganisms associated with the stomach and ileal surface.

C.botulinum colonizing the gut surface of the infant mouse
Bar: 2 µm

Chromatographic equipment for microbial identification and analysis of food constituents and metabolites

Salmonella

Removal from live chickens

R.F.Adams
Patricia L.Conway
R.L.Jones

Salmonellosis in chicken flocks is a significant source of salmonella food poisoning in humans. Feeding studies with erythrosine, a food colour known to inhibit the association of some bacteria with the gut surface, showed that under laboratory conditions erythrosine can prevent or eliminate colonization by *Salmonella typhimurium* of the caecae of chickens aged 1-8 weeks. No detectable residues of erythrosine could be found in the flesh of treated birds. There was no difference in taste between the flesh of treated and control birds.

Pasteurization of dressed chickens

P.G.Gwatkin
W.G.Murrell

Pasteurization of dressed birds aims at eliminating or lowering the incidence and level of contamination of *Salmonella* on the chicken carcass. Ozone in the atmosphere at concentrations of 1500 ppm and at pressures up to 10 psi consistently failed to give reductions in salmonellae of more than 90%. Aqueous solutions of 10 ppm were no more efficacious. Dips in ethanol solutions at various temperatures and concentrations reduced the salmonellae by 98-99% without affecting the skin. At higher concentrations and temperatures, reductions of 4 log units were achieved but skin damage resulted.

Spores

Location of cations in bacterial spores

J.A.Lindsay
W.G.Murrell
A.P.Somlyo[8]
A.V.Somlyo[8]
M.Stewart[9]

Location of major ions in spores prepared under various conditions was examined by high resolution scanning electron microscope analysis. Si, previously observed in the coat layer of *Bacillus cereus*, was not present in the coat of *B. coagulans* spores. *B.cereus* spores produced without Si were apparently less stable than those with Si. Although Ca has been located primarily in the protoplast of three species of spores, some was found in the coat of *B.coagulans*. The effect of spore cleaning procedures and nutrient conditions during sporulation on element distribution is being investigated.

DNA state in the spore protoplast

B.A.Cornell
J.A.Lindsay
W.G.Murrell

Model system studies using ^{31}P- and ^{13}C-n.m.r. revealed that DNA equilibrated at various a_w exhibited different T_1 motions above 0.63 a_w and below 0.38 a_w. This transition in motion probably indicates a change in the state of DNA. When equilibrated in the presence of dipicolinic acid (DPA) or CaDPA at various a_w, DNA exhibited the slower motion suggestive of the A state. These results suggest that the stability of nucleic acids within the spore protoplast may involve interactions between nucleic acids and DPA or CaDPA.

Stability of nucleic acids

J.A.Lindsay
W.G.Murrell

The heat stability of DNA was measured by heat denaturation profiles (T_m). *In vitro* analysis using conditions simulating those within the spore protoplast, i.e. high cation and DPA content, revealed that the T_m could be increased slightly in the presence of some ions. DPA/CaDPA, however, increased the T_m dramatically and under some conditions the DNA did not melt.

In an *in vitro* RNA synthesis system, DPA/CaDPA effectively stopped all RNA synthesis. The action of DPA/CaDPA resembles that of acridine dye binding to nucleic acids.

Model building of DNA/(DPA/CaDPA) complexes suggests that several DPA molecules may bind per base pair, totally encasing the polynucleotide and effectively stabilizing the molecule by reducing its motion within the spore.

Chemistry of radiation resistance

J.A.Lindsay
W.G.Murrell

Changes in u.v.-induced photoproduct type and amount were examined during sporulation in several *Bacillus* species. The relationship between type and amount of photoproduct and optimum growth temperature (OGT), spore death temperature (SDT), G/C and DPA content were also studied.

Results reveal more photoproducts than previously known. The type and amount may be directly related to species with altered genomes and reduced OGT and SDT. Spores from mutant *B.cereus* containing no DPA showed different patterns from their wild type parent. When DPA was added exogenously to the sporulation media of the mutants a photoproduct was produced which was a combination of thymine and DPA. This result suggests a direct interaction between the DNA and DPA in the developing spore.

N.m.r. studies on the water state of spores

J.H.Bradbury[10]
B.Hammer[10]
J.A.Lindsay
W.G.Murrell

The present phase of the proton n.m.r. studies on water state in spores has been completed. Transverse relaxation rates indicated that even though the mobility of water in the spore is about 10^{-4} of that in dilute aqueous solutions, the water in the spore protoplast is apparently more mobile than that adsorbed in coat and coat + cortex preparations. These results, together with the water sorption data of Watt and previous water permeability studies, strongly suggest that the protoplast is no drier than the outer integuments and that heat labile spore components may not be stabilized by preferential dehydration of the protoplast.

Molecular motion of DPA

B.A.Cornell
Sandra K.Meldrum
A.D.Warth

3-Fluoro-dipicolinic acid and ^{13}C-dipicolinic acid were synthesized and incorporated into *B.cereus* spores. Preliminary n.m.r. studies indicate that there is no free soluble dipicolinate in spores and that the fluorine groups are relatively immobile within the spore.

Stabilization of enzymes

Sandra K.Meldrum
A.D.Warth

Enzymes in spores are substantially protected from heat inactivation. In principle, stabilization could be caused by the presence of stabilizing substances in the spore, or by a low water content in the spore, or both. Studies with glucose-6-phosphate dehydrogenase in *B.cereus* spore extracts were continued, and show that this enzyme was stabilized to an extent similar to that in spores, by reduction of the a_w to 0.73, which gave a water content of 20% at 85°C. Removal of low molecular weight solutes, including CaDPA by gel filtration, did not significantly affect the heat stability or the water content of the spore extract at 0.7 a_w. Hence CaDPA does not appear to have a direct role in the stabilization to heat, or to be dominant in binding or excluding water in the spore interior. Two other spore enzymes and ovalbumin were also studied and all were greatly stabilized at reduced a_w.

Development of heat resistance

Sandra K.Meldrum
A.D.Warth

Changes in the heat stability of enzymes and the heat resistance of the organism during spore formation are being studied in *B.cereus*. A small change was observed early in spore formation, but the major increase in stability occurred in the final stages. These changes will be examined

in relation to the biochemical events occurring during development of the spore cortex.

Differential scanning calorimetry

J.E.Algie

Preliminary studies at Michigan State University indicated the potential usefulness of this technique for studying the melting temperatures of crystalline spore polymers and relating these to the heat resistant properties of spores. Studies on the softening of DNA, spore cortex and coat material at various water activities were started.

NUTRITIONAL STATUS AND QUALITY OF FOODS

Adiposity in broiler chickens

R.L.Hood
P.E.Walton

High energy diets fed to broilers to obtain rapid weight gains result in excessive fat deposits. Knowledge of the biochemical and cellular aspects of fat metabolism are expected to lead to methods to minimize this deposition. The relationship between adipose cell size and lipogenesis is being analysed.

Metabolism of fatty acids

A.C.Fogerty
G.L.Ford
S.Kozuharov
Denice Svoronos

Studies on the metabolism of geometrical and positional isomers of unsaturated fatty acids continued. A study of the metabolism of elaidic acid (*trans*-9-octadecenoic acid) in the rat indicated that the acid was largely oxidized, with some being deposited unchanged in the tissues. There was no evidence for accumulation of C12 or C14 β-oxidation products in the tissues, nor of products of ω-oxidation, nor of hydrogenation to stearic acid in the lower gastrointestinal tract.

When monogastric animals are fed propyl esters of α- or β-eleostearic acids, intestinal biohydrogenation takes place almost exclusively at carbon atoms 13 and 14. Thus the fatty acids produced following the ingestion of α-eleostearic acid (*cis*-9,*trans*-11,*trans*-13-octadecatrienoic acid) and β-eleostearic acid (*trans*-9,*trans*-11,*trans*-13-octadecatrienoic acid) are the *cis*-9,*trans*-11- and *trans*-9,*trans*-11-octadecadienoic acids respectively.

The lipids of livers of Australian infants who died from the Sudden Infant Death Syndrome (cot death) and other causes are being analysed with a view to relating their fatty acid composition data to other variables, such as liver biotin levels.

Analytical methods

G.L.Ford
Denice Svoronos

The Group participated in a working party (WG-18) set up by IUPAC to study the method of analysis of erucic acid (*cis*-13-docosenoic acid) in the presence of other docosenoic acid isomers.

High density lipoprotein (HDL)

J.R.Ashes[11]
R.W.Burley
J.B.Davenport
G.S.Sidhu

Investigations showed that feeding of diets, rich in lipids protected against microbial degradation in the rumen, to lactating cows results in the modification of plasma HDL. The average size of HDL particles increases with a concomitant rise in the concentration of cholesterol and β-carotene, the latter being exclusively localized in these particles. This change is associated with suppression of the

transfer of β-carotene to milk from the blood plasma although the concentration of circulating β-carotene is elevated. The properties of the modified HDL are being investigated further to gain insight into the mechanisms involved in β-carotene transfer from the plasma to milk and uptake by *corpus luteum*.

Nutritional availability of cross-linked amino-acids

J.R.Ashes[11]
G.S.Sidhu

Efficiency of protein utilization by ruminants can be optimized if proteins are protected against ruminal degradation by cross-linking in such a manner that the amino-acids contained therein are later readily released for absorption in the lower gut. Milk proteins carrying label in specific amino-acids, such as ^{14}C-lysine, ^{3}H-tyrosine, ^{14}C-leucine or ^{35}S-cysteine, were prepared by infusing singly or in combination these amino-acids into the jugular vein of a lactating goat. Labelled Fraction-I leaf protein was prepared by feeding either ^{35}S or $^{14}CO_2$ to lucerne plants. These proteins were cross-linked using different levels of formaldehyde and infused into the abomasum of sheep with Cr-EDTA as a marker, and samples taken at the terminal ileum. When treated with 2% formaldehyde, up to 35% lysine, 20% tyrosine and 32% cysteine remained unabsorbed from these proteins while the absorption of leucine, whose side chain does not react with formaldehyde, was only slightly affected. From the untreated protein over 96% of these amino-acids were absorbed. The unabsorbed amino-acids were present in the digesta presumably as short peptides. This work is being extended to find the optimum levels of formaldehyde treatment for different feed proteins consistent with a high amino-acid availability in the lower gut.

Biotin and Sudden Infant Death Syndrome (SIDS)

G.S.Heard
R.L.Hood
A.R.Johnson

Examination of infant livers from the UK indicated a reduced level of biotin in the livers of infants who died of SIDS (cot death). Livers of Australian infants are being analysed.

Infant formulations from the UK and Australia were analysed for biotin. Some formulations, particularly those based on cow's milk and modified to simulate human milk, were low in biotin. The biotin level of human milk was found to be variable and responsive to changes in diet.

Fatty acids in seed oils

J.R.Vickery

Analysis of 42 seed oils from 11 plant families showed that dihydromalvalic acid occurred in small amounts (0.1-1.2%) in 27 oils. The acid tended to occur in greater concentration in oils containing cyclopropene fatty acids.

FOOD STRUCTURE

The Food Structure Group is studying the intramolecular and intermolecular forces that control the structure of foods, and the relationship between the physical and functional properties of foods and their structure.

The major components responsible for the structural integrity of most foods, other than fruits and vegetables, are lipids, proteins and water, so initial efforts are being concentrated on systems involving only these three components. The principal proteins chosen for study are those

found in eggs since the properties of these proteins have a dominant effect on the reactions that take place during the cooking of all egg products.

Proteins and lipids in water can aggregate spontaneously to form colloids or emulsions and these have a considerable effect on the texture and stability of food. A method of measuring the minute forces that lead to the stabilization of emulsions has been developed and the effects that the incorporation of different proteins and lipids have on the stability of foods can now be studied.

Some lipids, when suspended by themselves in water, can form bilayer structures if some mechanical energy is supplied. These bilayers closely resemble the membranes that constitute the outer walls of the cells in food. Consequently, these bilayer membranes are much studied in an attempt to understand the role that membranes perform in controlling the properties of foods. The Group is examining the effects of incorporating proteins and other molecules into these membranes.

For convenience, the research work of the Group is divided into the three areas: proteins, colloids, and membranes, although in practice a particular research project may have elements of all three within it.

Proteins

Egg yolk apoproteins

R.W.Burley
R.W.Sleigh

Two studies have been undertaken to learn more about how proteins and lipids interact in yolk. (i) Yolk lipid has been dispersed in a solution of the major yolk lipoprotein. It was found that the apoproteins in some of the lipoprotein particles had been rearranged to form membranous layers around globules of lipid. (ii) The principal yolk apoprotein, apovitellenin I, has been treated with lecithin. Under some conditions a well-defined lecithin-protein complex was formed whose properties could be interpreted in terms of the theory of Mattice for the interaction of detergents and proteins. In additon to these studies, a new method for isolating the yolk apoproteins, involving hydrophobic chromatography, was developed.

Proteins of the vitelline membrane

Joan F.Back

The vitelline membrane, which surrounds the yolk of an egg, becomes fragile as the egg gets older and frequently breaks when it is opened. Two changes in the protein composition of this membrane have been found when old eggs were compared with fresh eggs: (i) the 'methionine-free protein' (described recently in the literature) can easily be extracted from fresh membranes, but is absent from similar extracts of old membranes, (ii) a new protein is present in the salt extracts of old membranes. This protein is a stable dimer of lysozyme according to the amino-acid composition and molecular weight. It is not certain how the dimer is stabilized but disulphide bonds do not appear to be responsible.

N.m.r. studies of phosphoproteins

R.W.Sleigh

The advantages of using phosphorus n.m.r. are: (i) the position of resonance is sensitive to ionic environment, bond angles and magnetic environment, (ii) the process of measurement does not perturb the sample. Information on

lipid-protein structures and phosphoproteins in egg yolk and other foods is being obtained in this way. Results so far indicate that the phosphate groups of phospholipid attached to the high-density lipoprotein of egg yolk are immobilized, whereas those attached to the low-density lipoprotein are completely mobile. In each case, increasing the salt concentration alters the resonance position of the phosphate group.

Egg white proteins

Ly Nguyen
M.B.Smith

Coagulation of egg white on heating is caused mainly by denaturation of ovalbumin (the major protein) followed by its aggregation to form a gel or precipitate. The first reaction is conveniently measured by scanning calorimetry, which also shows endothermic peaks corresponding to the other egg-white proteins and may be used to measure the conversion of ovalbumin to more heat-resistant forms (S-ovalbumins) on storage.

It was found possible to observe the aggregation process separately from the denaturation reaction. The effects on aggregation of temperature, protein concentration, pH, ionic strength and interactions with the other proteins are being studied by means of gel rigidity and viscosity measurements.

Applications of egg protein science

R.W.Burley
Ly Nguyen
M.B.Smith

For many years the Division has been accumulating new scientific information about egg proteins and how they react to conventional methods of handling and storage. Much of this information can also be applied in assessing unusual treatments for processing and storing whole egg, egg-white and egg yolk, or in developing new products. For instance, previous work on the thermal stability of egg-white proteins is relevant to considering their function in cookery and to developing new pre-cooked egg products.

A grant has been received from the Poultry Research Advisory Committee to support the extension of both basic and applied aspects of this work on egg-white and egg yolk.

Colloids

Stabilizing forces in colloidal suspensions

L.R.Fisher
R.A.Gamble
D.A.Haydon[12]
N.S.Parker

The stability of foods depends on the interactions between their components. Many foods, for example milk, margarine and butter, are emulsions, i.e. suspensions of small liquid droplets. Whether emulsions separate into oil and water phases, or whether they remain as emulsions, depends on the forces between these liquid droplets. Similar forces may govern cellular interactions, and hence control the stability of a wide variety of biological materials used as foodstuffs.

To understand, and hence to control, these stabilizing forces, a project designed to measure the force between cellular materials such as membranes was started. A novel laser interferometer, capable of measuring the very small distances involved, has been designed and built at FRL. This apparatus has been used in the laboratories of Professor D.A.Haydon in Cambridge, UK, to follow the interactions between thin hydrocarbon films protected by a variety of surface active materials similar to those that protect emulsion droplets from coalescence. A later visit to FRL

by Professor Haydon allowed further development of the apparatus by providing sophisticated electrical measurements for monitoring the changes in area of the droplets.

Pectin gels

D.G.Oakenfull
N.S.Parker

Although pectin is used extensively in the food industry as a gelling agent, the factors responsible for the strength and stability of pectin gels are not understood. A detailed study of the mechanism of formation of pectin gels was therefore started.

In practice, ordinary pectin requires the presence of high concentrations of sugar (60-65% of the total weight) to form gels. Gels have been prepared in the presence of other organic solutes and the strengths of these gels measured under compression using an Instron Universal Testing Machine. The results suggest that hydrophobic interactions are important in stabilizing pectin gels.

Microemulsions

D.G.Oakenfull
M.B.Smith

Microemulsions are minute droplets of an oil dispersed in water and stabilized by surfactants. They are excellent models for low density lipoproteins and other naturally occurring oil-in-water dispersions. Microemulsions have been prepared in which the dispersed oil phase is stabilized by lecithin and *tert*-butanol. The physical properties of the dispersed oil closely resemble those of the bulk liquid.

Rheological study of the staling of bread

G.E.Hibberd[13]
N.S.Parker

It is generally accepted that the major changes in texture of bread as it stales are caused by redistribution of the moisture and recrystallization of the starch. The commonly used measure of texture is a single point determination of firmness or softness in compression.

Measurements made in compression using the Instron Universal Testing Machine show that bread has complex time- and strain-dependent rheological properties. Furthermore, these properties and their changes on staling depend on the direction of measurement and the position of the test sample within the loaf. A range of rheological parameters, including the force at various stages of compression, the work done in compression and the work recovered, have been measured. The results have been analysed statistically to determine the interactions between factors such as position in the loaf, direction of measurement, rate of compression and position of the loaf in the proofing cabinet and oven.

Saponins in foods

Dorothy E.Fenwick
D.G.Oakenfull
D.L.Topping[14]

Saponins are steroid or triterpene glycosides which occur in a wide variety of plants, a few of which are used as food by man. Dietary saponins are known to lower plasma cholesterol concentrations in several species of animals. Saponins remain within the gastrointestinal tract and there are two possible mechanisms by which they could affect lipid metabolism. (1) Some, but not all, saponins form a complex with cholesterol. Since this complex is unlikely to be absorbed, its formation would cause direct elimination of cholesterol by faecal excretion. (2) There is evidence that, because saponins are surface-active, they induce binding of bile acids to dietary fibre. This would increase the loss of bile acids by faecal excretion and consequently increase the conversion of cholesterol into bile acids by the liver.

Purified saponins isolated from soybeans or quillaja bark (*Quillaia saponaria*, a South American tree) increase faecal excretion of bile acids and reduce plasma cholesterol concentrations in cholesterol-fed rats. Quillaja saponin is particularly effective at reducing plasma cholesterol because it operates by both mechanisms - it complexes directly with cholesterol and also induces faecal excretion of bile acids. Soysaponins, on the other hand, do not complex with cholesterol.

Quillaja saponin is an approved food additive which is used in small quantities as an emulsifier and foaming agent in such products as ice cream and soft drinks.

Membranes

The function, structure and physical properties of most biological substances are determined at some stage in their development by the properties of a membrane. Understanding the manner in which membranes are assembled and how they perform their various tasks is therefore central to understanding the physical behaviour of biological materials and the response of these materials when they are harvested, stored and processed into foods.

Protein mobility

B.A.Cornell
J.B.Davenport
Frances Separovic
M.Stewart[9]
P.Yeagle[15]
R.Smith[16]

One of the important and until recently inaccessible properties of biological membranes is the molecular motion undergone by the membrane-bound protein and the influence the supporting lipid matrix has in determining this motion. ^{13}C proton-enhanced magic-angle spinning n.m.r. is currently being used to measure directly the amplitude and timescale of motion of individual segments of protein molecules within membrane preparations. An ultimate goal is to relate the protein mobility to the tasks performed by proteins within biological membranes and to develop a detailed picture at the molecular level as to how membranes function.

Preliminary results employing these techniques were obtained using dispersions of cholesterol, polypeptide or a variety of proteins with lipids such as dimyristoyl phosphatidyl choline (DMPC) in both the fluid and crystalline phases. Proteins studies in this manner included glycophorin phospholipase A_2, ribonucleose, lysozyme, cytochrome oxidase, and cytochrome C.

Conformation and location of polypeptides

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G.W.Francis
D.Ramsey[2]
Frances Separovic
Loretta Weir

To provide both a basis on which to interpret the molecular motion data described above and as a study in its own right, X-ray and neutron diffraction are being used to identify the average location of various polypeptide and, ultimately, protein segments within phospholipid membranes. By employing deuteron labels, neutron diffraction provides the unique ability to locate the position of the labelled groups within the repeating unit of the membrane structure. Initially, this work is concentrated on identifying the location of the tryptophan groups of the polypeptide gramicidin A within a variety of model membrane structures having different hydrocarbon thicknesses and fluidities.

Effect of proteins on packing geometry of lipid bilayer membranes

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B.H.Kennett
Frances Separovic
Loretta Weir

There is very little information available on the physical consequences of membrane systems being subjected to perturbation. One basic question, the answer to which is essential to understanding the basic structure of membranes, is: which component in the membranes dominates its dimensions? Does a protein molecule change its conformation in accordance with the geometry of the supporting lipid bilayer, or does the bilayer distort to accommodate the protein or do both occur?

An answer to this question will be sought using a number of techniques, including X-ray and neutron diffraction, photon correlation light scattering and high precision dilatometry. Preliminary experiments have begun in which the interaction between the polypeptide gramacidin A and synthetic phospholipids such as DMPC are being studied.

Low frequency motion in biological membranes

B.A.Cornell
G.W.Francis
Frances Separovic

A novel and fascinating result of studies carried out in this laboratory is the observation of a component of motion within lipid bilayer membranes which occurs on the milli- to micro-second timescale and which is enhanced by the inclusion of cholesterol, polypeptides or proteins. As many of the activities performed by membranes at the physiological level occur on a similar timescale, a series of experiments were started that were directed towards characterizing this motion and relating it to the function performed by a membrane-included molecule, such as an ionophore that can transport ions across a membrane.

Oxidative stability of biomembranes

M.A.Brown
J.M.Gebicki[2]

By incubating human erythrocytes in the presence of α-tocopherol, good absorption into the membrane can be achieved. If the suspending medium is washed free of excess vitamin such that only the membrane-bound vitamin remains, the cells are found to be several orders of magnitude more resistant to hemolysis when exposed to an oxidizing environment such as gamma radiation. A clinical trial in progress will determine whether supplemental α-tocopherol produces the same effect.

PLANT PHYSIOLOGY

The aim of this group is to solve current and anticipated postharvest problems of the fruit and vegetable industries of Australia. To this end the Group works on both long-term furdamental aspects and short-term problems of more immediate concern to the industry. There are six sub-programs: cell physiology, membrane structure and function, chilling injury in plants, postharvest handling and storage of fruits and vegetables, mechanisms of fruit ripening and electron microscopy.

Cell physiology

Understanding the maintenance of fruits and vegetables in an acceptable postharvest condition requires a knowledge of the responses of plant cells to stress and the processes of senescence. A model system, namely the regulation of the synthesis of the leaf enzyme ribulose bisphosphate carboxylase/oxygenase, is being used as a test-bed before application of the findings to the fruit ripening system.

Protein synthesis in wheat leaves

C.J.Brady
Elizabeth Lee
J.Speirs

The contents of translatable mRNA for the small subunit of ribulose bisphosphate carboxylase in ageing wheat leaves precisely parallel the turnover rates for the subunits measured *in vivo*. Negative evidence was gained concerning the possibility that, in older leaves, the mRNA for the small subunit lost translatability due to loss or modification of the cap structure. Available evidence suggests a transcriptional control mechanism.

Salts, inorganic osmotica and protein synthesis

C.J.Brady
T.Gibson[2]
J.Speirs

Observations were made on the influence on protein synthesis *in vitro* of a variety of inorganic salts and a range of those organic solutes that commonly accumulate in water-, salt-, or cold-stressed plants. In general, the organic solutes inhibited protein synthesis less than did the inorganic salts; the protein synthesizing system was particularly tolerant of high concentrations of glycinebetaine. Most of the products of translation of wheat leaf RNA by a wheat germ translation system were affected similarly by any inhibiting solute, inorganic or organic. However, a small percentage of products were made maximally at solute concentrations that differed from the modal optimum.

Preparative systems for proteins

P.B.H.O'Connell

A system for the purification of fragile proteins for use in analytical and immunochemical experiments was developed. Characteristics designed into this system were: (1) the protein of interest was segregated rapidly from harmful constituents of the homogenate, (2) the protein was always maintained in a similar solution environment and specifically no aggregation or dehydration processes were used, and (3) total preparation time was kept as short as possible. The system was applied to the purification of ribulose-1,5-bisphosphate carboxylase/oxygenase from green leaves of wheat, tobacco and alfalfa. The supernatant from a homogenate, clarified for five minutes in an air-driven ultracentrifuge, was loaded onto polyacrylamide gels. The enzyme band, visualized as a refractile zone, was sliced from the developed gels, homogenized and extracted in a small electrodialysis device. Final concentration onto a sloping semi-permeable membrane was by electro-decantation. Three milligrams of enzyme, prepared in less than eight hours in a constant buffer medium, can be obtained.

Membrane structure and function

Membranes are vital components of the cell and research by the Group has shown that they are important in determining the sensitivity of plants and their fruits to chilling injury. Accordingly, fundamental studies are being made of the effects of temperature on the properties and functions of plant cell membranes, including mitochondrial, chloroplast and plasmalemma membranes. A wide range of techniques is being used to study the physical properties of the membranes, and their biological functioning is being studied by measuring enzymic oxidative and photosynthetic activities. A consideration of these properties leads to the conclusion that the lipids are important in determining the effect of temperature on the behaviour of membranes.

Thermal phase transitions

J.K.Raison
Lesley C.Wright

The transition temperature for the highly unsaturated lipids that form the major components of plant membranes is well below 0°C. This suggests that the transitions observed in the membrane lipids of chilling-sensitive plants above 0°C by spin and fluorescence labelling involve only a small

proportion of the more saturated lipids which have high transition temperatures. To determine if such saturated lipids can interact with the bulk polar lipids of plant membranes to produce cooperative transitions, the effect of adding dipalmitoyl phosphatidyl choline (DPPC, transition temperature 41°C) on the thermal properties of polar lipids from wheat was studied by differential scanning calorimetry. The addition of as little as 1% DPPC induced transitions with the main exotherm beginning at about 8°C, similar to the exotherm observed with polar lipids from mung bean, a chilling-sensitive plant. Increasing the concentration of DPPC induced additional transitions at higher temperatures but no transition for free DPPC was detected. At 20% DPPC the main transition began at 22°C but calculations of the enthalpy showed that no more than 10% of the total lipid was involved in the transition. The results indicated that all of the added DPPC forms a cooperative melting mixture with the lipids from wheat but the composition of the mixture varies with the concentration of added DPPC. Dimyristoyl phosphatidyl choline (DMPC, transition temperature 23°C) also induced transitions in wheat polar lipids. However, the main exotherms were at 0°C and 7°C and changed little with increasing concentrations of DMPC.

Lipid composition and phase transitions

J.K.Raison
Lesley C.Wright

The onset of the calorimetric exotherm for the polar lipids from mung bean hypocotyl tissue occurs at about 8°C, the critical temperature for the growth of this chilling-sensitive plant. It also coincides with the temperature for the transition detected by spin labelling and fluorescence spectroscopy of the polar lipids. To determine which lipid components are responsible for the thermal transitions, the polar lipids were separated into three fractions and the calorimetric properties of these investigated. All three fractions, even that containing most of the monogalactosyldiglyceride plus traces of neutrals, were essential to produce a single transition at 8°C. The fraction containing all the phospholipid and most of the digalactosyldiglyceride showed a series of transitions over the temperature range of 0° to 30°C.

Plasma membrane ATPase

E.J.McMurchie
M.K.Pomeroy[18]
J.K.Raison
Lesley C.Wright

The potassium-stimulated adenosine triphosphatase (K^+-ATPase) is an intrinsic protein of the plasma membrane of plant cells and is thought to be the active pump responsible for ion accumulation. Studies with intact tissue show that the Arrhenius activation energy for ion uptake increases below about 12°C with chilling-resistant as well as chilling-sensitive plants. Such response to low temperature is atypical of enzymes associated with membranes of chilling-resistant plants and prompted an investigation of the thermal properties of the membrane and enzyme system. A membrane fraction rich in K^+-stimulated, Mg^{2+}-dependent ATPase activity was isolated from the buds of cauliflower, a chilling-resistant plant. The membranes contained 61% phospholipids, 12% sterol and acylated sterol-glycosides, and 27% neutral lipid of which 8% was free sterol or sterol esters. There was little contamination of the plasma membranes with chloroplast or mitochondrial membranes and the high sterol:phospholipid ratio (0:5) was similar to that from some other plant plasma membrane preparations. Arrhenius plots of the K^+-ATPase were biphasic with an increase in

activation energy below 12°C, similar to plots of ion accumulation in whole tissue. No thermal transition or change in molecular ordering was evident in the membranes or the membrane lipids when examined by differential scanning calorimetry and e.s.r. The change in kinetics at chilling temperatures is thus an intrinsic property of the enzyme and is not dependent on a change in lipid ordering. The marked decrease in the rate of ion accumulation by both chilling-resistant and sensitive plants at low temperature is probably a direct effect of temperature on the kinetics of their K^+-ATPases. However, since the growth of chilling-resistant plants is not disproportionately impeded below 12°C the increase in activation energy and the marked decrease in rate of this enzyme below 12°C is not rate limiting for growth.

Lipid-protein interactions in chloroplast membranes

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Janette R.Kenrick
I.R.Willing[19]

Further studies using both monolayer and ^{13}C-n.m.r. techniques established that interaction of proteins and lipids in the chloroplast membrane may depend more on hydrophobic interactions and hydrogen bonding than on electrostatic interactions which are assumed to predominate in other biological membranes. The interactions of cytochrome *c*, melittin and ferredoxin reductase with chloroplast membrane lipids have demonstrated that the magnitude of these interactions varies with different proteins. Melittin, a polypeptide containing 26 amino-acids and devoid of enzymic activity, was shown to inhibit a number of membrane-associated activities in chloroplasts, including photosynthetic electron transfer and the establishment of an electrochemical gradient. The mechanism of this effect was shown to be a restriction in mobility of the membrane lipids.

Chilling injury in plants

Tropical and subtropical plants and their fruit, e.g. avocados, tomatoes, pineapples, pawpaws, bananas, are 'chilling-sensitive', that is, they are injured as a result of a relatively short exposure to temperatures below about 10°-15°C but above the freezing point of the tissue. Some temperate zone plants, e.g. certain varieties of apples, are also injured after prolonged storage at temperatures about 0°C. The physiology and biochemistry of this phenomenon are being studied to determine the causes of, and the means of ameliorating, the effects of chilling temperatures. This is of commercial importance, because low temperatures are the most satisfactory way of maintaining the quality of fruits and vegetables during transport and storage. The practical application of the information obtained is likely to be through plant breeding programs to introduce chilling-resistance into the susceptible species. Accordingly, assays for chilling injury, suitable for use by plant breeders, are being sought.

New studies are attempting to define the nature and extent of heat injury in plants and fruit crops and to develop methods for assay of heat damage. There is also some work on other stress situations including dehydration and high light stress.

Abnormal metabolism in plants during chilling

B.D.Patterson
Linda A.Payne
Judith A.Pearson

The genus *Passiflora* (Passionfruit) contains some species that are sensitive to chilling and some that are resistant. When leaves of several species were chilled, those from the chilling-sensitive species accumulated alanine, while the chilling-resistant ones did not. This difference in behaviour was also shown by chilling-sensitive and chilling-resistant genotypes of the single species *Passiflora edulis*. While chilling induced changes in other metabolites, most of the changes measured were shown by both genotypes. The effect of chilling on alanine levels appears promising as a metabolic indicator of chilling sensitivity.

Metabolic changes preceding chilling injury in fruits

W.McC.Bailey
B.D.Patterson
Linda A.Payne
Judith A.Pearson
K.J.Scott[5]

Tomato leaves were found to accumulate alanine when they were chilled, although the response was delayed when a more chilling-resistant genotype was investigated (a high-altitude variety of *Lycopersicon hirsutum*). Tomato fruits at the mature-green stage also showed this response. While the rate of alanine accumulation was slower in fruits than in leaves, this was consistent with the greater amount of chilling required by fruits before injury occurred. Some additives (e.g. Ca^{++}, phorone, geraniol) can hasten or delay the onset of chilling injury, and the effects of these additions on metabolic changes are being investigated in apples subject to low temperature breakdown.

'Freeze-clamping' apple tissue at -196°C before extracting metabolites

Selection for chilling-resistance in hybrid tomatoes

B.D.Patterson
Linda A.Payne

To permit the selection of genotypes of tomato with enhanced chilling-resistance, *L.hirsutum* (high altitude form) was crossed with *L.esculentum* and the F_1 hybrid backcrossed to *L.esculentum*. The more fertile of these hybrids were then grown for seed. Aseptically germinated seedlings were chilled at various temperatures and divided into groups which were least and most injured by the chilling stress. The selected populations were then grown through a generation and their progeny tested again. The chilling-resistance appeared to be inherited and therefore the method offers promise as a selection technique.

Cold-sensitivity of PEP carboxylase

D.Graham
D.G.Hockley
B.D.Patterson

This project aims to determine the way in which chilling temperatures affect the function of soluble enzymes in plants, in particular phosphoenol pyruvate (PEP) carboxylase. This enzyme from a number of tropical plants (e.g. *Passiflora* spp. and *Lycopersicon* spp.) which have the C3 pathway of photosynthesis has been shown to be cold-sensitive. It has a disproportionately diminished activity at temperatures below about 10°C compared to the enzyme from plants of temperate zone genera such as *Caltha* sp. (an Australian alpine) and *Pisum sativum* (garden pea). It has now been found for both tropical and temperate plants that the enzyme is activated by the glycolytic intermediate glucose 6-phosphate (G6P) but only at physiological concentrations of PEP. This suggests a mechanism by which tropical species may overcome the cold-sensitivity of the enzyme. An increase in G6P concentration at low temperatures in tropical species would permit continued operation in the cold of this important anaplerotic enzyme supplying carbon skeletons to the tricarboxylic acid cycle, a process required for growth of the plant cell.

In vivo operation of PEP carboxylase in the cold

T.ap Rees[12]
D.Graham

PEP carboxylase is cold-sensitive when isolated from chilling-sensitive and chilling-resistant members of tropical genera such as *Passiflora* and *Lycopersicon*. The possibility that the *in vitro* cold-sensitivity of the enzyme is an artefact of isolation has been tested by *in vivo* studies on Andean wild tomato (*L.hirsutum*) ecotypes varying widely in their chilling-sensitivity. The fixation of $^{14}CO_2$ was compared at 25°C and 5°C in leaves in the dark, when the primary fixation of CO_2 is *via* PEP carboxylase. Both the chilling-sensitive and the chilling-resistant ecotypes were about equally affected by the cold and $^{14}CO_2$ fixation was greatly reduced in both cases. This is consistent with the cold-sensitivity of PEP carboxylase which is apparent *in vitro*. This appears to be only the second time that the cold-sensitivity of a plant enzyme has been verified at the whole plant level and related to the metabolism of the plant in the cold.

Screening for chilling tolerance

E.R.Cousins
G.W.Francis
Suzan E.Hetherington
Robyn Nott
N.S.Parker
R.M.Smillie
G.Stanley
Mary E.Willcox[6]

A non-destructive screening procedure has been developed for following chilling injury, the hardening of plants to chilling and for identifying chilling tolerance. Up to 96 samples of mature plant tissue (leaves or green fruit peel) can be screened at any one time. The maximal rate of the rise in chlorophyll fluorescence of variable yield is recorded for each sample with approximately two-second readings. This rate decreases as cellular chilling injury develops and the time at 0°C for a 50% decrease is taken as a measure of resistance to chilling injury. Fluorescence kinetics are measured using a portable fluorometer and recorded on cassette tape *via* a 'Simtrad' device, designed at FRL, for later reply through the Simtrad to a computer programmed for determination of fluorescence rates and their statistical analysis.

Screening for chilling tolerance in a breeding program of maize

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A.Hardacre[20]
Suzan E.Hetherington
R.M.Smillie

In this joint project with maize breeders at the Plant Physiology Division, DSIR, NZ, the screening procedure for chilling tolerance utilizing chlorophyll fluorescence was tested in a plant breeding program. A line of Corn Belt Dent, the most widely grown maize, was compared with a line of the Northern Flint Race, generally considered to be a source of genes for better germination and growth at low temperatures. Quantitative data were obtained for the first time demonstrating that Northern Flint possessed greater cool

tolerance. Even more tolerant was a maize originating in highland tropical regions of Peru. The same order of ranking was maintained when all three lines were each crossed with an accepted USA inbred tester line.

Chlorophyll fluorescence photography

G.C.Gibbons[21]
R.M.Smillie

Chlorophyll fluorescence photography with high speed colour film was used to detect mutants, chilling injury and heat stress. With suitable interference filter combinations and a light source, photography could be used to follow time dependent changes in the fluorescent yield in barley leaves. Subsequently, because the chilling of chilling-sensitive and tolerant plants induces differential decreases in the fluorescence yield, the rate of chilling injury in tomato, potato and tomato-potato somatic hybrids was compared using colour photography. In a similar manner both heat stress, which is accompanied by an increase in fluorescence in heated leaves, and naturally high fluorescing mendelian and maternally inherited photosynthetic mutants were detected. Protochlorphyllide-deficient and protochlorphyllide-accumulating mutants of barley were also identified with this sensitive technique.

Rapid assays for heat injury, resistance and hardening

G.C.Gibbons[21]
Robyn Nott
R.M.Smillie

Previously, chlorophyll fluorescence of constant yield (F_o) which is responsive to heat-induced changes in structure but not activity of chloroplast membranes, has been used to compare heat resistances of green plant tissues. Chlorophyll fluorescence of variable yield (F_v) is responsive to changes in photosynthetic activity and the use of this value to assess heat damage was investigated. F_v decreased as leaves became heat injured and was eventually abolished. In leaves heated at 1 deg C per minute, F_v was undetectable above 43°C in barley, 44°C in pea, 45°C in bean and in tomato, 49°C in maize and 51°C in papaya. In heat-hardened barley this temperature was increased by 6 deg C compared with unhardened barley. Measurement of F_v *in vivo* provides a rapid method for monitoring (a) the onset of cellular heating injury, (b) ranking plants for heat resistance and (c) following heat hardening. It has the potential for development as a screening test for heat tolerance in plant breeding programs.

Technique for selecting for temperature-stable oil composition in sunflower

D.G.Bishop
C.P.Rochester[22]

The linoleic acid content of sunflower oil is of economic importance and there is evidence that night temperature is a major factor in the control of linoleic acid synthesis in the plant. A study of the biosynthetic pathway of linoleic acid in sunflower seeds and of the effect of temperature on the individual steps was commenced.

Heat, cold and high light stress in *Borya*

Suzan E.Hetherington
R.M.Smillie

Tolerance to heat, cold and high visible irradiation was measured in *Borya nitida*, a poikilohydrous plant able to colonize rock outcrops and shallow sands in areas receiving high insolation. Heat tolerance was high, comparable to that of plants growing in Death Valley, California, USA. Unlike the Death Valley plants, *Borya* does not require prior acclimation by growth at high temperatures to achieve high heat tolerance. *Borya* was also tolerant of a temperature of 0°C and could acclimate to resist photoinhibition at high visible light irradiances.

Ultrastructural changes in plastids of *B.nitida*

Suzan E.Hetherington
R.M.Smillie

Leaves of *B.nitida* turn yellow when the plant is dehydrated but regreen following rehydration. Dehydration of the leaves was found to induce the degradation of chloroplast thylakoids; in dry leaves plastids resembled etioplasts. Following rehydration, however, the etioplasts differentiated into chloroplasts. Plastid development was, therefore, seen to be cyclical and it was proposed that this rarely observed phenomenon was a means by which the plant conserved energy when exposed to environmental stress.

High light stress (photoinhibition in cucumber)

Christa Critchley[10]
Robyn Nott
R.M.Smillie

Cucumber leaves grown at low light intensity or in shade became damaged when exposed to full sunlight. After three to five hours of irradiation, damage to leaves was irreversible and resulted in tissue death. Absorbance and chlorophyll fluorescence measurements showed that intense irradiation inhibited photosynthetic electron transfer and that the sensitive site in intact tissue was located on the oxidizing side of photosystem II. In particular, chlorophyll fluorescence provided a fast method for estimating photoinhibitory damage and will be applied to determine whether green fruit may be similarly damaged.

Postharvest fruit and vegetable storage and handling

The development of practical strategies for postharvest storage of fruit and vegetables at both low and ambient temperatures continues to be an important aspect of the Group's activities. Application of the postharvest calcium treatment to prevent the disorders bitter pit and breakdown in Australian apples is continuing. Postharvest maturity standards for rockmelon are being developed. New studies on potato storage have begun to determine the biochemical changes during storage at low temperature. Enzymic indices of storage capacity, particularly in relation to sugar accumulation, which is important for the potato processing industry, are being sought with a view to their application to potato breeding programs.

Tropical fruit storage and handling research continues, with work on avocados, bananas, mangoes and litchis.

Control of postharvest disorders of apples with calcium

W.McC.Bailey
J.B.O'Loughlin[23]
K.J.Scott[5]

Following studies throughout Australia and New Zealand, postharvest application of calcium chloride to control wastage in apples due to the physiological disorders, bitter pit and breakdown, was successfully adopted on an industry-wide basis for Granny Smith in Western Australia and Cox's Orange Pippin in New Zealand. There have been problems of skin injury with other varieties in some growing areas in Australia. Current investigations in association with NSW and Tasmanian Departments of Agriculture aim to develop commercially acceptable methods for overcoming the problem of skin injury in several important varieties.

Soft scald of apples

W.McC.Bailey
Glenda Hopkirk[24]
R.B.H.Wills[24]

Soft scald is a physiological disorder of cool-stored apples. In Australia the Jonathan cultivar is most affected. Studies over a number of seasons showed that the occurrence of the disorder is associated with the amount of alcohol (hexanol) in the fruit and that the disorder can be controlled by postharvest treatment of the fruit with methyl linoleate. Recent studies have shown that many substances related to methyl linoleate are also effective in controlling the disorder and that oil in water emulsions of edible fats or oils (2.4% oil) such as lard, palm and safflower oils also give

good control. The use of oil in water emulsions may have commercial possibilities for the control of soft scald.

Postharvest wastage of rockmelons

G.J.Marvell
S.C.Morris[5]
N.L.Wade[5]

Hot-water dip treatments control part of the disease complex that afflicts rockmelons. Heat presumably kills susceptible spores on the surface of the fruit. Studies have now been made of (a) the rate at which heat penetrates the rind of the fruit upon immersion in hot water, and (b) the *in vitro* susceptibilities to heat of pure isolates of organisms from the disease complex. The results will be correlated with the previous observations on wastage in hot-water dipped fruit.

Minimum maturity standard for rockmelons

G.J.Marvell
S.C.Morris[5]
N.L.Wade[5]

Objective criteria by which horticultural produce can be described for marketing purposes are often difficult to determine. The attributes chosen must correlate well with the requirements of the intended usage of the produce, and be easy to measure. So that an objective assessment of melon maturity can be made, the accumulation patterns of sugars and acids that contribute to flavour are being measured in fruit from diverse growing areas. Results from the current season will show if accumulation rates vary from place to place.

Storage of bananas in polyethylene bags at high ambient temperatures

W.B.McGlasson
K.J.Scott[5]
Sing Ching Tongdee[25]

As there had been reports from several countries in South-East Asia that the Australian-developed treatment (polyethylene bags and ethylene absorbent) was unsatisfactory for extending the life of bananas under the high ambient temperatures of the tropics, Mrs Tongdee re-evaluated the treatment. The polyethylene bag treatment was found to be effective at temperatures as high as 37°C provided that the fruit were not too mature.

Avocado processing

D.J.Casimir
G.R.Chaplin
G.J.Williams[1]

The avocado industry wishes to prevent fresh marketing of insect-damaged or misshapen fruit. Although these grades of fruit are less acceptable in the fresh market, the edible portions are generally unaffected and are potentially suitable for processing. Two preliminary trials were undertaken to determine the stability and acceptability of ripe avocado pulp in canned and frozen forms.

Peeled and de-seeded flesh was treated with a solution containing 75 ppm of sulphur dioxide for 10 minutes to prevent discoloration; it was then vacuum-steam blanched, puréed and portions were sealed into polyethylene bags and stored at -18°C. Other samples of purée that had been treated with citric acid solutions to give a pH of 4.1 were hot-filled into cans which were closed and cooled.

The frozen product maintained a bright green colour and typical avocado flavour during storage. The canned product had an acidic flavour and its bright green colour was lost. No obvious heat-induced bitter flavours were detected.

Biochemical changes in potato tubers during storage

D.G.Bishop
Janette R.Kenrick
Pattylou J.Walcott

A preliminary study of the activity of the enzyme, lipolytic acyl hydrolase in potato tubers and changes in its activity during storage was completed. Six varieties were selected for more detailed measurements and have been grown in the field. Levels of reducing sugars, lipolytic acyl hydrolase and phosphofructokinase are being monitored during storage at 8°C, to establish whether the activities of

the two enzymes can be used as an index for storage capacity. Lipolytic acyl hydrolase was purified and its interaction with membrane lipids is being studied.

Cooling of fresh produce

G.B.Morgan
N.L.Wade[5]

Some problems associated with the commercial cooling of fresh produce are being studied, with emphasis on the requirements for efficient operation of refrigeration plant. The lack of a comprehensive guide for use by coolroom operators was noted, and such a guide is currently being prepared in collaboration with the Engineering Section.

Mechanisms of fruit ripening

To attain high quality most soft fruits should not be harvested until ripening has begun. However, the subsequent shelf-life of these fruits may be relatively short. The objectives of current research are to understand the mechanisms of fruit ripening and to devise new methods of regulating the onset and rate of ripening. The work is being extended to include the study of the relation between the biochemical changes associated with ripening and quality and to use this information to improve consumer acceptability and nutritional quality.

Pectin metabolism in tomato fruit

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C.J.Brady
G.A.MacAlpine
W.B.McGlasson
Y.Ueda[26]

It has been proposed that, in tomato fruit, pectin catabolism catalysed by the hydrolysing enzyme polygalacturonase (PG) plays a vital role in predisposing fruit to ripen. To test this hypothesis, changes in activity and in amount of the isozymes of PG were measured in extracts from a series of fruit at different stages of ripeness. PG was not detected until at least one day after the beginning of the climacteric rise in respiration and the associated increase in ethylene production. The first isozyme to appear has a molecular weight of 100 000 but two smaller isozymes, M_r 43 000 and M_r 46 000, account for the large increases in PG measured in the interval four to seven days after the climacteric commenced. Endogenous activity was measured as an increment in water-soluble uronic acid, and this was significant only in fruit four or more days into the climacteric period. Synthesis of PG in the tomato fruit is thus a secondary event in the sequence of biochemical changes associated with ripening, and it is not clear whether PG activity has a role in ripening other than promoting wall softening. Differences in the relative activities of the isozymes *in vivo* could contribute to differences among strains in the rate and extent of softening. The relative amounts of the large and small isozymes are being measured in fruit of F1 hybrids of the non-ripening mutants *rin* and *nor* and in a firm-fruited commercial cultivar.

Quality evaluation of fresh market tomatoes

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G.A.MacAlpine
R.L.McBride
W.B.McGlasson
D.J.McGrath[27]
N.S.Parker
J.B.Sumeghy[5]

The aim of the studies is to improve the quality of fresh market tomatoes offered to the Australian public. A large number of advanced imported lines and some bred locally were grown in field trials at Hawkesbury Agricultural College, Richmond, NSW, and assessed against a standard commercial cultivar (Floradade). The lines were assessed initially in the field on the basis of plant and fruit type, fruit colour and apparent yield. At this stage all of the F1 hybrid strains incorporating the *nor* gene were rejected because of poor colour development. It appears that it will be necessary to incorporate colour-enhancing genes to increase the level of lycopene. Eleven of the remaining lines were tested for titratable acidity, firmness, shelf-life and consumer acceptability. None proved statistically

better in quality than Floradade. In limited observations on six of the best lines, ripe fruit lost flavour to about the same extent as Floradade during one week's storage at 20°C.

Floradade has been criticized by consumers for lack of flavour and its tough texture. The effects of harvest maturity and ripening temperature on acceptability of Floradade and Walter, an older cultivar, were examined. Fruit (150-200 g) grown at Bowen, North Queensland, were selected from freshly harvested lots at the mature green and breaker (first red colour) stages of ripeness and transported by road or rail under refrigeration to Sydney, NSW, and stored at 13°C or 20°C until table ripe. Shipments were staggered so that all fruit reached the table ripe stage on about the same day. A trained panel (24 people) rated the fruit for colour, texture, flavour and overall acceptability. There were no significant differences between treatments and fruit of both cultivars were judged acceptable.

Electron microscopy

Joan M.Bain

A wide variety of plant and animal material was examined by light and/or electron microscopy in collaborative studies which included:

- The structure of bacterial flora associated with the gut surface of rats, the structure of yeast cells and the structure of bacterial spores;
- Chilling injury in flesh of avocados;
- Sun scald in Granny Smith apples;
- The structure of the apoprotein of avian egg yolk;
- The structure of the vitelline membrane in hens' eggs;
- The monitoring of samples prepared for biochemical work, e.g. liposomes.

GOSFORD HORTICULTURAL POSTHARVEST LABORATORY

This Laboratory is operated jointly with the NSW Department of Agriculture. In addition to studies on postharvest fruit and vegetable problems, it is also responsible, under the auspices of the Fresh Fruit Disinfestation Committee, a joint Commonwealth and State body, for work on insect disinfestation of fresh fruit.

Fungicide investigations

Fungicide behaviour in commercial dips

N.Ahmad[5]
K.R.Ward[5]
B.L.Wild[5]

The fungicide guazatine is presently used extensively in citrus packinghouses throughout Australia to control sour rot and *Penicillium* moulds that develop on fruit during marketing. However, the fungicide is expensive and, because of its highly reactive nature, quickly lost from the dip solutions, making it difficult to maintain effective dip strengths.

Studies on the chemistry of this compound have shown that its tendency to bind to dirt particles could be reduced by lowering the pH from the normal 6.5 to 3.5. However, at this pH it was not known if fungicidal efficacy was maintained. A series of tests was conducted in which the efficacy of dips at different concentrations and pH were tested for ability to control green mould, *Penicillium digitatum*. Results have shown no differences in the dosage responses of guazatine at varying pH. This indicated that commercial dips containing guazatine can be acidified to pH 3.5, thus resulting in an extension of the dip life, without a reduction in efficacy. Further tests will be conducted to determine if this will occur in commercial practice and if dip tanks can be protected from the acid solution.

Resistance screening

B.L.Wild[5]

The existence of green mould strains resistant to the benzimidazole fungicides necessitates their detection in citrus packinghouses so other fungicides can be selected that will give mould control. The use of *in vitro* culture provide a quick method of detecting these strains. However, no clear relationship was found between the level of resistance occurring commercially and the *in vitro* tolerance of these strains.

By studying dosage responses of resistant and sensitive strains of mould, the concentration of the fungicide in the media can be determined which will permit selective detection of all commercially significant resistant strains, without counting sensitive strains. Initial data in these experiments indicate that a concentration of 2 µg/ml methylbenzimidazole carbonate (MBC) permits 90% growth of benzimidazole resistance strains yet prevents growth of sensitive mould strains. Further work will test other resistant mould strains to determine their dosage-response and see if they are detectable in media containing 2 µg/ml MBC.

Blue mould resistance

B.L.Wild[5]

Isolates of blue mould *P.italicum* were taken from a packinghouse that had reported poor mould control with the fungicide guazatine. The strain isolated was found to cause infection in oranges treated with 6000 µg/ml of the fungicide. The treatment used was 12 times the recommended concentration that would normally give excellent mould control. In dosage-response studies on media containing the fungicide this strain was found to have an ED_{50} concentration of 10 µg/ml compared to 0.1 µg/ml for the sensitive strain.

It is suspected that the blue mould strain resistant to guazatine is closely related to the species *P.expansum* which causes blue mould decay on apples. This mould is also unaffected by the fungicide guazatine. Initial studies on some of these isolates of the resistant strain from oranges showed that they also appear to be infective on apples. Further work is required to confirm this.

Fungicide screening

B.L.Wild[5]

During investigations into methods of improving the performance of the fungicide guazatine it was noticed that the addition of acetic acid to acidify the dip also reduced mould development in the control treatment. Further studies have now shown that good control of mould can be achieved

with a postharvest dip of 2% v/v acetic acid. Increasing the pH of the acetic acid dip to 8.5 by the addition of sodium hydroxide has not reduced the effectiveness of the dip and it appears that the acetate ion is the component affecting mould control. Other members of the monocarboxylic acid series have been tested and have also been found to reduce mould development: di- and tri-carboxylic acids did not.

The mode of action of the acetate ion is being studied.

Control of *Aspergillus niger* in onions

S.C.Morris[5]

Severe losses of onions over the last few seasons, due mainly to *A.niger*, have brought into question the economics of the industry in the Murrumbidgee Irrigation Area and the techniques used for the storage of onions. Initial screening of several control measures has indicated that artificial curing and the fungicides benomyl, thiram, BTS 40542 and CGA 64251 give good control.

Vegetable storage

Potato greening

S.C.Morris[5]

A rapid h.p.l.c. analysis for glycoalkaloid content has been developed enabling all possible glycoalkaloids to be analysed within 2-6 minutes. Screening of a large number of potato cultivars and breeding lines has revealed most have safe levels but one cultivar and several breeding lines have dangerously high levels. Several light and chemical treatments are showing promise of controlling both chlorophyll and glycoalkaloid synthesis.

Operating a high performance liquid chromatograph to separate solanin from greening potatoes

Postharvest tomato rots

S.C.Morris[5]
N.L.Wade[5]

Initial screening for postharvest pathogens indicated the presence of *Alternaria*, *Fusarium*, *Erwinia* sp. and *Geotrichum candidum*. *G.candidum* was the major pathogen in several consignments with high wastage. Chlorine, BTS 40542 and captan gave only partial control of *G.candidum* on coloured fruit.

Disinfestation investigations

Fumigation of lemons with ethylene dibromide (EDB)

S.C.Morris[5]
L.E.Rippon[5]

The distribution and concentration of EDB during a standard 2-hour fumigation was determined using Eureka lemons rather than Valencia oranges.

Three dose rates, 24 g/m^3 (20°C), 32 g/m^3 (15°C) and 41 g/m^3 (10°C), were used. About one-third of the initial dose was absorbed by the chamber walls and about one-third by the cartons. However, the absorbance by lemons was about 50% higher than for Valencia oranges, with 17.9%, 16.3% and 13.4% of the initial dose being absorbed by the lemons at the respective dose rates.

EDB fumigation of grapefruit

C.J.Rigney[5]
R.J.Smith[5]

In attempting to establish the most tolerant stage of Queensland fruit fly in Marsh grapefruit, infested fruit were treated with 8 g/m^3 EDB at 20°C. This treatment achieved 100% mortality on 65 000 eggs and 41 000 young larvae. Two surviving old larvae of 40 000 treated indicate that in grapefruit old larvae are the most tolerant of EDB treatment. One hundred percent mortality of old larvae was subsequently demonstrated on treating 250 000 insects at an EDB dose of 15 g/m^3 at 20°C.

EDB fumigation of mandarins

C.J.Rigney[5]
R.J.Smith[5]

Treatment of infested Ellendale mandarins with EDB doses of 16 g/m^3 at 20°C, 21 g/m^3 at 15°C and 27 g/m^3 at 10°C achieved 100% mortality on Queensland fruit fly treated as 140 000 eggs, 180 000 young larvae and 180 000 old larvae in the fruit. Residue and phytotoxicity studies are currently being undertaken with this EDB fumigation schedule.

TASMANIAN FOOD RESEARCH UNIT

The Tasmanian Food Research Unit (TFRU) is concerned specifically with fish technology. The Unit is increasingly becoming a centre for advice to fishermen, processors, regulatory agencies and consumers.

Advice based on past research on the processing of abalone, squid and rock lobster, fish silage production and mechanical separation of fish flesh is regularly sought. More recently the fishing industry has required information on fish chilling and storage as it affects trawler design, marketing of less familiar species of fish, and packaging and presentation for supermarkets.

Relationships of rate of food spoilage to temperature

A.Ball[28]
C.A.Curran[29]
R.Lowry[6]
T.A.McMeekin[28]
June N.Olley
A.R.Quarmby
D.A.Ratkowsky[6]
R.M.Storey[30]

Japanese workers have established a linear relationship between the square root of the rate of nucleotide breakdown and temperature. A similar relationship has been found to apply to growth rates of a wide range of bacteria, yeasts and moulds.

This relationship takes the form $\sqrt{r} = b(T-T_o)$, where r is the rate, b is the regression coefficient, and T_o is a notional temperature that is an intrinsic property of the phenomenon being measured. It does not necessarily imply the temperature of cessation of change, because below the freezing point changes in rate may be due to both temperature and water activity.

Psychrotrophs studied had a T_o in the range 260-270°K, mesophiles 270-280°K and thermophiles 290-296°K.

The relationship between spoilage rate and temperature for proteinaceous foods, which was derived empirically at TFRU in 1972 from data sets in the literature, was found to obey the square root relationship up to 288°K (15°C) with a T_o of 263°K. This shows the psychrotrophic nature of most food spoilage.

Tropical fish have mesophilic bacteria, but work in collaboration with the Tropical Products Institute, London, UK, indicates that once tropical species have been iced, psychrotrophic spoilage ensues. Two species of tropical bream, gold-lined sea bream (*Rhabdosargus sarba*) and the threadfin bream (*Nemipterus japonicus*) which had been flown to London on ice for subsequent storage at higher temperatures had T_o values of 265.5°K and 261.6°K respectively. These T_o values represent rates of spoilage at 10°C that were 5.5 and 3.8 times faster than at 0°C.

A portable battery-operated temperature function integrator has been designed for TFRU by the Humber Laboratory, Ministry of Agriculture, Fisheries and Food, UK, from data supplied by TFRU. The output from this device, which is in accord with the square root relationship with a T_o of 263°K, is read from a micro-coulometer.

Chilled storage of trawl fish

I.A.Stafford
S.J.Sykes
S.J.Thrower

In Australia, the developing trawl fisheries are yielding hauls of unfamiliar species of fish. There is no reliable information on the relative effectiveness of ice, refrigerated sea water (RSW) and chilled sea water (CSW) storage for these species, and so an apparatus has been designed and built to enable comparative storage trials to be carried out. It can also be used for instruction and demonstration purposes.

The system is a recirculating one; water is drawn from the surface of a horizontally-baffled reservoir tank, cooled by a 'Riple Plate' heat exchanger and returned through a sump in the base of the tank. For mobility, the equipment is trailer-mounted and can use domestic electric power.

RSW is pumped from the sump into two fish storage tanks through sparge pipes in the base of each tank and returned to the surface of the reservoir tank through V-notched weirs. Temperature is controlled by regulating both water

flow and refrigeration system. A parallel system of sparge pipes permits the introduction of gases into each fish tank. Extra tanks can be used to hold fish in ice and CSW.

A thermodynamic model of the apparatus is being developed for use in the design of refrigeration systems for fishing vessels.

Identification of fish by electrophoresis

H.A.Bremner
A.M.A.Vail

Electrophoresis of fish proteins provides a suitable 'fingerprint' for identification of species. Optimum conditions for extraction and electrophoresis were established. A limited reference set of fingerprints has been collected, which can be used by a skilled operator to make tentative identifications. A national collection would, however, be unwieldy.

Slight variations occur with different runs and for positive identification a correctly identified sample should be included each time.

Freezing as a means of long-term storage of authentic samples is not suitable since the proteins may denature. Attempts are being made to modify a freeze-drying technique to obtain rehydratable extracts.

LIAISON AND EXTENSION

Kathryn H.Adams
G.Fisher
K.C.Richardson
P.J.Rutledge
G.J.Walker

The transfer of an experienced food technologist to the Liaison Section has increased the Section's capacity to cope with the steady stream of inquiries received from the food industry. The response to many industry inquiries is restricted to the providing of appropriate published information. When necessary, however, experimental work is undertaken and on-site assistance is given. This is particularly so with trouble-shooting assignments.

The Section has also been able to take a more active role with the Plant Physiology Group in examining some problems associated with the storage of prepared fresh vegetables and delicatessen items.

Public awareness of FRL's activities has increased and the demand for consumer leaflets has been maintained.

MEAT RESEARCH LABORATORY

Research grouping

Severe difficulties in funding led to the loss of six professional and support positions from MRL during 1980. Continuing shortfall in salary funds will necessitate the loss of further positions as they become vacant.

In an attempt to make the maximum use of resources available, the seven relatively small sections at MRL were regrouped into two large sections, Muscle Biology and Meat Science and Technology. It is intended that the smaller, common interest groups within the main sections will be sufficiently flexible to allow the highest priority research to continue as manpower availability decreases.

New processing facility

The new processing facility opened on 24 July 1980 comprises the following:

- Holding pens/dry landing area

  There are five cattle pens and one sheep pen (all under cover, with lighting to Department of Primary Industry (DPI) requirements), a digital weight crush, and knocking boxes for sheep and cattle.

- Slaughter area

  This is designed to meet DPI standards for conventional bed-dressing. There is ample space for experimental work.

Sheep dehorning and head-skinning display

Overhead rails are used to transport the dressed carcasses to the new chillers and freezer or to the chillers and freezers in the adjacent building.

The area is cooled by a large evaporative cooling system.

- Cold stores

  There are two chillers and one freezer. One chiller is designed to hold about 20 beef sides, while the other is for general purpose use and has rack and shelf storage as well as the usual overhead rails. The chillers can provide storage temperatures from -2°C to +10°C. The freezer is capable of a storage temperature of -20°C.

- Viscera room

  This is designed for the treatment of viscera to DPI standards, as well as for experimental work.

- Boning room

  This area has provision for boning of quarters or sides on a conventional rail system. There is a large amount of space available for the testing of equipment, and large items can be moved into and out of the area with the use of a 2-tonne monorail crane. The whole area is refrigerated and can be kept at 10°C.

Demonstrating 'hot-boning'

- New plant room

  This room contains refrigeration plant for the chillers and freezers as well as for air-conditioning the process area.

- Store

  This is provided for process equipment storage.

PROCESS ENGINEERING

Abattoir waste treatment

Sludge utilization

J.K.Connor[27]
L.S.Herbert
B.V.Kavanagh

The poor performance of dried waste activated sludge (WAS) in chicken feeding trials was a major setback in the development of a process to utilize WAS as a protein supplement in stock feed (see Report of Research 1979-80). The use of polyelectrolyte to condition the sludge during filtration, with subsequent concentration of polyelectrolyte in the dried WAS, was a possible reason for its poor nutritional performance - surface-active materials are known to affect digestion in chickens. Another batch of 100 kg of dried WAS was prepared by filtering sludge, conditioned with ferric chloride, on a band-press filter, and drying the dewatered sludge by heating it with tallow in a pilot-scale, dry-rendering cooker. Chicken assays done at the Yeerongpilly laboratory of the Queensland Department of Primary Industries showed that dried WAS had a very low nutritive value, acting virtually as an inert filler in the chicken rations. Extensive inquiries have failed to explain these poor nutritional characteristics. Work on this project and on sludge dewatering was terminated.

Band-press filter used to dewater WAS

Survey of an activated sludge treatment plant

L.S.Herbert
S.M.Travers

Work on aspects of the operation and performance of an activated sludge plant treating waste-water from a local abattoir continued. Normal operation of the plant was disrupted by low and intermittent production from the abattoir, and the main effort was to establish correlations between the results of various analytical tests used to monitor plant performance. The 5-day Biochemical Oxygen Demand (BOD_5) test is complex, time-consuming, and of no value for on-line control, as results are not available until five days after the sample is taken. Linear regression analysis

of values of BOD_5, Chemical Oxygen Demand (COD) and Suspended Solids (SS) contents showed that, for untreated water from an abattoir, a good correlation exists between BOD_5 and COD (r=0.95) and COD and SS (r=0.92). There is a reasonable correlation between BOD_5 and SS (r=0.72). For the treated waste-water leaving the activated sludge plant, there is a good correlation between COD and SS (r=0.98) and reasonable correlation between COD and BOD_5 (r=0.69). COD and SS tests can be done in about three hours and one hour respectively, and could therefore be used to monitor effluent treatment plant performance, with only occasional BOD_5 tests required to check correlations.

Laboratory-scale activated sludge plant

K.R.Davey
B.V.Kavanagh
D.A.Lovett
S.M.Travers

The initial experiments described in Report of Research 1979-80 are now complete. The aim of the work was to provide basic design data on sludge filtration and settling for plants treating high protein wastes, particularly abattoir wastes. The nutrient feed used in the experiments was a commercial beef concentrate. In general, the experimental plant gave good treatment efficiency and produced a sludge which settled satisfactorily at sludge ages above about six days. The filterability of the sludge was inferior to that reported for domestic sewage, but could be improved at greater sludge ages by treatment with cationic polymers.

Further experiments, using abattoir waste-water as nutrient feed, are in progress. The effects of dissolved oxygen concentration, feeding pattern (intermittent or continuous), and fat concentration in the abattoir waste-water on system performance and sludge quality are also being studied. So far, results at high concentrations of dissolved oxygen (4 mg/l) with continuous feeding, are in agreement with data obtained using the beef concentrate. However, when dissolved oxygen concentrations were held below 0.3 mg/l, only about 60% of the fat in the feed was metabolized, compared with 90% at concentrations near 4 mg/l, and differences in plant performance became evident. Interestingly, the lower concentrations of dissolved oxygen gave better effluent quality.

Particular attention is being given to the influence of filamentous organisms in producing sludges that settle poorly (bulking sludges). The degree of bulking is being assessed by the usual macroscopic parameters of sludge volume index, zone settling velocity and capillary suction time. An attempt is being made to correlate these with microscopic evaluation of the sludge. Usually, experiments done at low concentrations of dissolved oxygen (< 0.3 mg/l) have yielded bulking sludges. Higher concentrations (4 mg/l) produced sludges with good settling characteristics.

Fat hardness

K.R.Davey

The hardness of fat on chilled carcasses entering the boning room is often the cause of industrial disputes in Australian abattoirs. Hard fat is difficult to cut and increases the dangers of knife work. Some abattoirs attempt to overcome this problem by boning carcasses which have a cool deep meat, but a warmer surface fat. At present, fat hardness is determined subjectively by the foreman or 'referee', usually by pressure with the finger.

A study is under way to characterize the sensory impressions of the expert with an objective measure of hardness. An attempt has been made to simulate the cutting action of a knife edge during boning. The test apparatus consists of a cutting edge which is dragged through a stationary sample of fat. The cutting edge starts from rest and comprises a cylindrical blade held at 90° to the sample. The time taken for the blade to travel a fixed distance is used to define a hardness number in terms of fundamental units of either stress or power. The aim is to develop a simpler, hand-held instrument for *in situ* measurement.

Fat content

K.R.Davey

There is an urgent need for a simple, inexpensive device for determining the fat content of cartoned meat rapidly and non-destructively. Its use would enable closer compliance with buyer specification, with consequent economic advantage.

A device, which measures the fat content of cartoned, boneless meat *in situ* and has the potential for continuous and automatic monitoring, is being developed. The study will attempt to exploit the difference in densities of the lean and fat. The suggestion for utilization of this principle is not new but a major difficulty in the past has been the accurate measurement of sample volume and weight. It is hoped that recent advances in commercially-available measurement technology may permit measurements with the required degree of accuracy.

pH measurement in meat

J.Anderson
W.Larnach
S.M.Travers

In experiments involving the electrical stimulation of beef carcasses, a large number of pH readings on meat samples was required in a short space of time, i.e. up to 800 in 5 hours. To provide these data, a 'pistol' has been developed which houses a micro-electrode. The sealed barrel of the pistol can be forced into the sample, through the fat layer, to a pre-set depth. On pulling a trigger, the active tip of the electrode is exposed to the meat sample and the pH is recorded. On release of the trigger, the electrode is again sealed in the barrel and the pistol is withdrawn from the sample. This device facilitated much faster pH data collection and greatly reduced inaccuracies due to fat smearing the electrode and due to operator error. The hole made by the pistol closes almost completely, leaving carcasses visually undamaged.

Demonstration of new beef processing techniques

L.S.Herbert
C.F.Thomas[31]
R.W.Tritchler
K.Visser[32]

An Australian Industrial Research and Development Board contract with consulting engineers, K.Visser and Associates Pty Ltd, to develop a prototype automatic plate freezer was extended to include the development and demonstration, on a commercial scale, of a beef production line incorporating a package of new techniques. These include electrical stimulation, carcass decontamination, hot-boning and automatic plate freezing. An abattoir close to Brisbane agreed to participate in the work, and staff from MRL are assisting by guiding the program and investigating various aspects of processing. Comments were made on the design of the prototype freezer, and a test in which cattle bodies were electrically stimulated on the bleeding rail, then hot-boned after a short chilling period, was completed.

Electrical stimulation

J.Anderson
L.S.Herbert
D.T.Kerr
W.K.Larnach
S.M.Travers
G.L.J.Wescombe

More than 40 rectal stimulation units operating at low voltages (below 35 V RMS) have been sold in Australia, mainly to small slaughterhouses. The firm in Brisbane that manufactures these units has received many inquiries from overseas and units have been sold in Japan.

The high-voltage stimulation unit installed at an abattoir near Brisbane has been in operation continuously since May 1980, treating up to 350 cattle per day on a gravity rail. Carcasses remain stationary during stimulation in a cabinet on a section of rail between hide-pulling and evisceration, with stimulation applied at about 12 minutes after stunning. Operation of the unit was monitored by measuring the pH of stimulated carcasses in three locations in the *longissimus dorsi* muscle, two in the lumbar region and one in the thoracic region. pH was also measured at the same locations in unstimulated carcasses. Measurements were taken approximately 1¼ hours after stunning. Values of approximately 7.0 were usually obtained for unstimulated carcasses, and lower values (down to 5.50) for stimulated carcasses. A difference of about 1.0 pH unit between the stimulated and unstimulated pH values was taken to indicate effective stimulation.

In general, meat from carcasses judged to have been effectively stimulated on the basis of pH decrease was found by laboratory evaluation with a Warner-Bratzler shear and a taste panel to be more tender than unstimulated meat. In a series of tests, effectiveness of stimulation was assessed when current flow-path was from hind leg-to-hind leg and from neck-to-hind legs; pulsing rates from 7-29 pulses per second; for voltages from 100 to 1200 V RMS; and for stimulation times from 15 to 120 seconds. It was found that 300 V RMS, peak current 2-3A, a current flow-path from neck-to-hind legs, 14.3 pulses/second, and 45 second duration, represented the lowest voltage and shortest duration required, at this abattoir, for effective stimulation. These conditions did not provide effective stimulation if time from stunning to stimulation was longer than about 15 minutes.

A comprehensive Guideline Document, which should allow an abattoir to select the correct stimulation conditions to suit its needs, is being issued.

Extra low voltage stimulation

D.T.Kerr
G.L.J.Wescombe

The rectal system of applying extra low voltage stimulation has been further developed to effectively stimulate the striploin and cube roll. These cuts do not receive any significant stimulation when the rectal probe alone is applied. By applying a nostril electrode in addition to a rectal electrode, the electrical current path now includes the cube roll and striploin. Commercial trials of the system are in progress.

Dehorning and head skinning of sheep

D.T.Kerr
G.L.J.Wescombe

The concept of removing the horns from beneath the pelt is still being pursued. The pelt is removed conventionally down to the horns as far as possible. A machine which cuts the horns from the skull, allowing the complete head skin to be removed by pulling down to the nostril, had been developed previously but in operation it was too slow for commercial use.

A new machine that can keep up with high-speed production lines (8 sheep/minute) was built and is being tested.

Another machine, which clamps the pelt after the horns are cut, and pulls it down over the head to complete the head-skinning operating is being developed. This machine will complement the dehorning machine and relieve the operator of much of the effort required.

BIOCHEMISTRY

Metabolic studies

Effect of electrical stimulation on calcium uptake by cell organelles

R.P.Newbold

The rate of pH fall in muscle after stimulation is faster than in unstimulated muscle. This reflects a higher concentration of sarcoplasmic calcium in stimulated muscle and suggests that the calcium-accumulating ability of the sarcoplasmic reticulum (SR), the mitochondria, or both, is diminished. Earlier work indicated that a low-voltage stimulation method in which the voltage was stepped from 10 V to 110 V in four steps over four minutes did not affect the ability of the SR to take up calcium, but did reduce the amount of respiration-linked calcium uptake and the rate of adenosine triphosphate-linked uptake by mitochondria. Evidence has now been obtained that high-voltage stimulation (1100 V peak for two minutes) reduces the calcium uptake activity of both the SR and the mitochondria.

Electrical stimulation pathways

Heather C.Morton
R.P.Newbold

The neuromuscular blocking agent, curare, was used to study the pathways by which electrical stimulation is transmitted in sheep carcasses. Changes in pH and in inorganic phosphate, ATP, creatine phosphate and hexose monophosphate concentrations in four different muscles were used as measures of the effectiveness of stimulation.

Sheep were subjected to one of three treatments - none, intravenous nembutal or intravenous nembutal and curare, two to five minutes before slaughter.

The dressed carcasses were immediately stimulated with either high or low voltage, using penetrating electrodes in the upper hind legs and neck. A low voltage (45 V, 40 pulses per second) rectal stimulation before dressing was also included in the program. High voltage (600 V, 14.3 pulses per second) electrical stimulation resulted in an increased rate of pH, ATP and creatine phosphate decline, and an increased accumulation of inorganic phosphate in all muscles at any given time. The hexose monophosphate concentrations were not markedly different after stimulation. There was no significant difference between any of the drug treatments with high-voltage electrical stimulation, thus indicating that a functional nervous system is not necessary under these conditions. The effects of low voltage (45 V, 14.3 or 40 pulses per second) hind leg-to-neck, or rectal stimulation were similar although not as dramatic as the high voltage. However, in marked contrast, the effect

of low-voltage stimulation can be inhibited by the curare treatment. There was no significant difference in the parameters measured with time post-mortem between unstimulated carcasses from animals that had not been treated with curare and stimulated carcasses from curare-treated animals. This suggests that a functional nervous system is necessary for low-voltage stimulation to be effective.

Biology of ruminant adipose tissue

Cellular studies

G.W.Johnson
T.W.Larsen
R.F.Thornton
R.K.Tume

Some of the difficulties encountered in preparing isolated adipocytes from sheep adipose tissue were outlined previously. It is now evident that large cells, e.g. diameters of the order of 200 µm, have very fragile membranes that are readily damaged by collagenase digestion. The purity of commercial collagenase preparations varies markedly and each batch must be tested to ensure that viable, metabolically-active cells are isolated.

Fat deposition during growth

G.W.Johnson
T.W.Larsen
R.F.Thornton
R.K.Tume

Fat metabolism in ruminant adipose tissue is a function of lipogenesis, incorporation of long-chain fatty acids, and lipolysis. The balance between these three processes determines the rate of fat deposition in or loss from the adipose tissue depots.

In a previous study of subcutaneous fat deposition in growing sheep, lipogenesis, as indicated by the rate of ^{14}C-acetate incorporation into lipid, could not account for the measured rates of fat deposition and the pattern of lipogenic response did not parallel that of carcass fat deposition. The implication of this finding was that the incorporation of long-chain fatty acids of dietary origin was contributing to fat deposition.

The rates of lipogenesis from both acetate and lactate incorporation, the rate of stearic acid incorporation, lipoprotein lipase activity, and the rate of lipolysis in adipose tissues of fattening, mature (>30 kg liveweight) sheep, were studied, and the data are being analysed.

Membrane studies

G.W.Johnson
R.K.Tume

Plasma membranes of cells from sheep omental adipose tissue were isolated by differential centrifugation of tissue homogenates and were further purified by density-gradient centrifugation in Ficoll/sucrose. The membranes were characterized by their density, and by their high specific activity of 5'-nucleotidase. A Ca^{2+} and/or Mg^{2+}-dependent ATPase was found in the membrane preparations, but the function of this enzyme has not been determined and it has not been linked to any transport process across the membrane. In the presence of Ca^{2+} and Mg^{2+}, the ATPase was not affected by the mitochondrial inhibitors, azide (10 mM) and azonide (1 mM), nor by the ionophores and uncouplers, gramicidin D (10 µM), carbonyl cyanide p-trifluoromethoxy phenylhydrozone (FCCP) (10 µM) and ruthenium red (7 µM), but was inhibited by oligomycin (2 µM). When added alone,

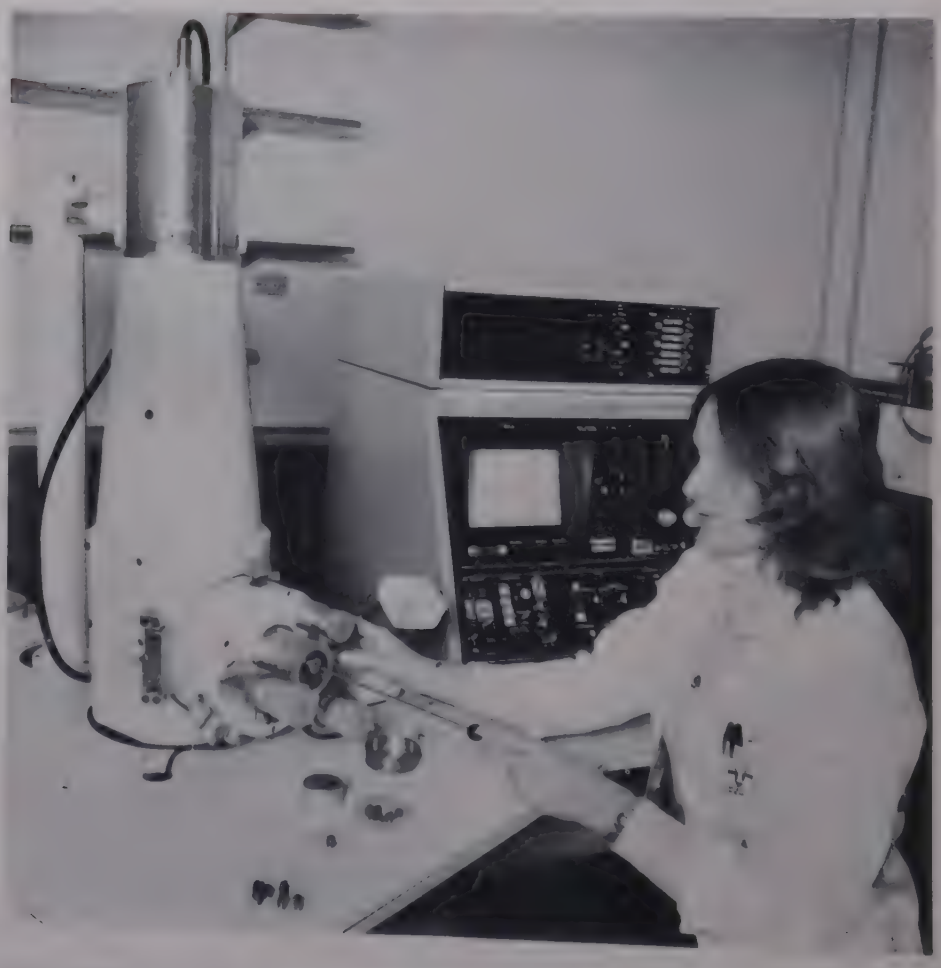
Ca^{2+} and Mg^{2+} were almost equally effective in stimulating ATPase activity. Concentrations of about 1 mM Ca^{2+} or Mg^{2+} were sufficient to saturate the enzyme (apparent half-saturation constant, $K_{0.5}$~0.1-0.2 mM). In the presence of 1 mM Ca^{2+} and no added Mg^{2+}, 1 mM ATP was required for maximum activity ($K_{0.5}$~0.04-0.08 mM). This was unchanged when Mg ATP (molar ratio of 0.5:1.0) was used as substrate. These findings suggest that the activity measured represents a rather low-affinity Ca^{2+}, Mg^{2+} ATPase.

MUSCLE GROWTH AND DEVELOPMENT

Muscle structure

R.W.D.Rowe

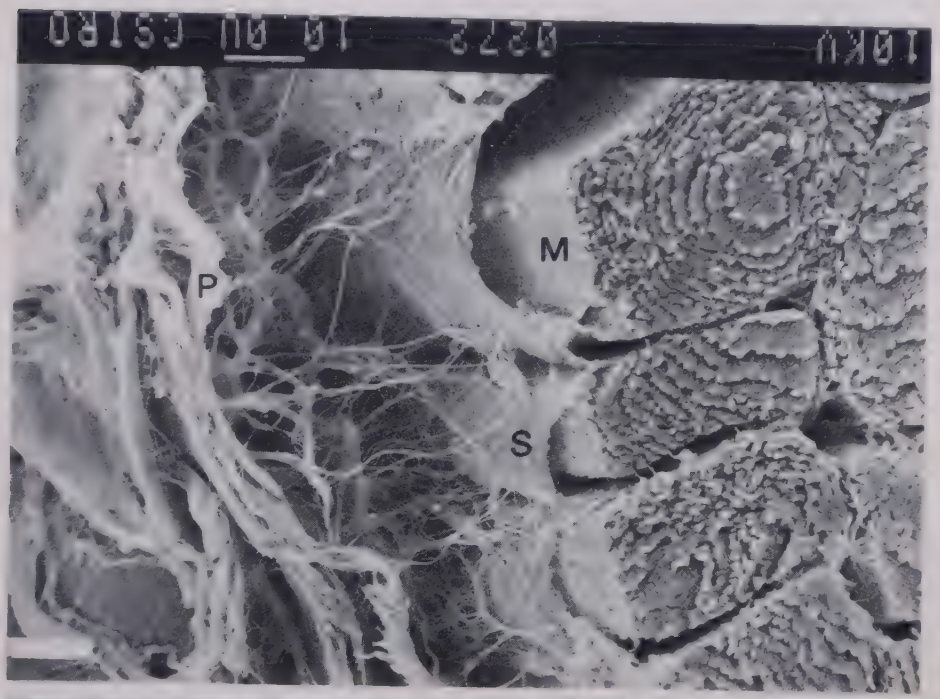
Scanning Electron Miscoscopy (SEM) has been used to re-examine the structure of collagen fibres and the relationships between muscle fibres and intramuscular connective tissue. So far, the data have confirmed those obtained using transmission electron microscopy and light microscopy. In addition, SEM has enabled additional constituents of the intramuscular connective tissue to be identified, particularly at the endomysial and fine perimysial levels of organization.



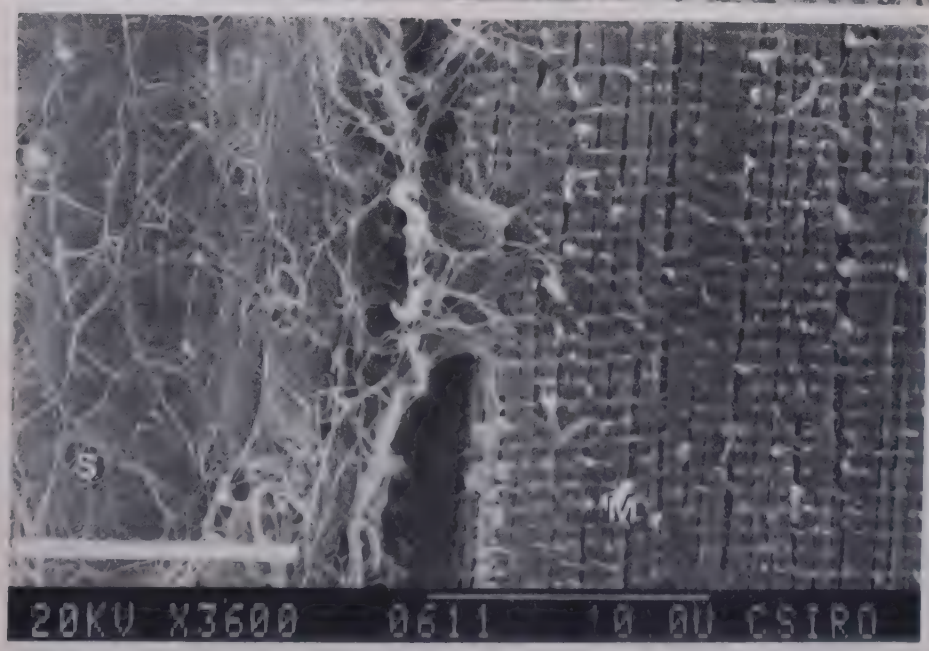
Operating the new scanning electron microscope

The structural consequences of cutting post-rigor meat samples before and after heating were studied using SEM. When raw samples are cut longitudinally with a sharp blade, the muscle fibres almost exclusively separate at the interface between neighbouring endomysial surfaces. In cooked samples, neighbouring endomysial/sarcolemmal sheets appear to have fused together, and the muscle fibres separate in a

plane just below the sarcolemma. The implications of these different planes of separation for the mechanical assessment of meat toughness are being studied.



Beef muscle (*Semi-tendinosus*) - End view
M: Exposed myofibrils of muscle fibre
S: Sarcolemma plus endomysium
P: Collagen of perimysium
Bar marker: 10 µm



Beef muscle (*Semi-tendinosus*) - Side view
M: Exposed myofibrils of muscle fibre
S: Sarcolemma plus endomysium
Bar marker: 10 µm

Electrical stimulation

R.W.D.Rowe
F.D.Shaw

Examination, with a light microscope, of muscle samples taken post-rigor from carcasses electrically stimulated pre-rigor confirmed that in the majority of cases there is a high incidence of contraction clots present in the muscle fibres. The presence of these contraction clots must cause adjacent sarcomeres to be longer than they would otherwise need to be. This extreme variation in sarcomere length within muscle fibres makes the assessment of the overall contraction state of a muscle difficult.

Sarcomere length data using different measuring techniques were collected in an attempt to further clarify whether or not electrical stimulation prevents cold shortening.

Sarcoplasmic reticulum (SR)

Basal ATPase

D.J.Horgan

SR preparations from rabbit white muscles, rabbit red muscles and pressure-treated rabbit white muscles, when centrifuged in sucrose density gradients, all contain a light sub-fraction in addition to the main protein bands. This sub-fraction has the highest basal ATPase activity of all the sub-fractions and is specifically labelled with tritiated ouabain. It therefore appears that the basal ATPase activity of SR preparations is largely due to sarcolemmal or T-tubule contamination.

Sodium dodecyl sulphate (SDS)-polyacrylamide gel electrophoresis

D.J.Horgan
R.Kuypers

The electrophoretic behaviour of the SR ATPase protein varies with the conditions used to denature the SR in SDS before electrophoresis on SDS-polyacrylamide gel slabs. Denaturation at 100°C reduced the amount of the ATPase protein and formed aggregates of high molecular weight. The other proteins of the SR, as well as myofibrillar proteins and bovine serum albumin, were unaffected by this treatment.

Enzyme binding

D.J.Horgan
R.Kuypers

The binding of phosphorylase and phosphorylase kinase, two key enzymes in muscle glycolysis, to SR vesicles, is being studied. Both enzymes appear to bind preferentially to the lightest sub-fraction of the SR. The properties of the bound enzymes and the effects of proteolysis are being investigated, as is the effect of pressure treatment on the properties of these enzymes, and their binding to SR and myofibrils.

Muscle differentiation

D.J.Morton
F.D.Shaw
J.F.Weidemann

Muscle cell cultures are being used to study the effects of different serum components on muscle differentiation. The cells are derived from foetuses and neonates of several species. One aim of the studies is to determine the conditions that favour the predominance of muscle growth over fibroblast growth. Immunofluorescence and SDS gel techniques are being used to show which proteins are present at different stages of growth.

MEAT SCIENCE AND TECHNOLOGY

Meat properties

Pressure-heat treatments

J.J.Macfarlane
I.J.McKenzie
T.Nakayama[33]
R.H.Turner

The pressure-heat treatment, that had been developed previously, appears to destroy the myofibrillar component of toughness, but the mechanisms by which the treatment achieves its effect are not known. There appear to be no reports in the literature of the effects of comparable pressure-heat treatments on proteins. To gain insight into the mechanisms involved, particularly with respect to limitations that may exist in the use of the treatment, the response of the major protein constituents of muscle to pressure-heat treatment is being studied.

Properties of pressure-treated muscle

J.J.Macfarlane
I.J.McKenzie
R.H.Turner

Further evidence for disruption of structural components of muscle under high pressure was obtained by observing the length changes induced by application of pressure to muscle supporting a load. These experiments were done with a windowed pressure vessel, and the length changes that occurred in the muscle were recorded with the use of a video recording unit which monitored the movement of a scale attached to the free end of the muscle. The studies showed that the tensile strength of post-rigor muscle at 0°-30°C is decreased when pressure is increased. Factors that may influence the response of the muscle, such as temperature, contraction state, time post-slaughter and ultimate pH, are being investigated. The response of loaded, pre-rigor muscle depended upon the temperature. At 30°C it contracted, but after some minutes stretched again. At 0°C, the cold-shortened muscle lengthened.

Comparison of buffalo meat and beef

P.E.Bouton
P.V.Harris
D.Ratcliff[6]
J.Robertson[34]
W.R.Shorthose

The tenderness of meat from domesticated buffalo (*Bubalus bubalis*) and Brahman (*Bos indicus*) cattle of similar age (51 months) was assessed using a number of different mechanical and physical methods, and taste panels. Colour measurements indicated that muscles from buffalo were darker than those of the Brahmans, even though there were no significant differences in ultimate pH. This difference was thought sufficient to disadvantage buffalo meat relative to beef if displayed together for sale. Assessments of the mechanical properties of cooked samples of muscles (*semitendinosus* and *semimembranosus*) with reasonably high contents of connective tissue indicated that buffalo meat was tougher than beef. This difference was due to a greater contribution of the connective tissue component to toughness in the buffalo samples. Taste panel assessment of muscles (*longissimus dorsi* and *psoas major*) relatively low in connective tissue content indicated that generic differences in toughness were slight, although buffalo meat was drier. It also had less flavour.

Pre-slaughter effects on animals and meat

Rail transport of cattle

R.H.Dickinson
R.Saal[35]
W.R.Shorthose

Between two and four cattle per thousand die during transport by rail in Queensland. The death rate appears to vary seasonally and temperatures during the journey may be responsible. In a joint study with the Queensland Meat Industry Organisation and Marketing Authority, air and surface temperatures within cattle wagons were monitored. The standard cattle wagons on Queensland railways ('K' wagons) have no roof and the effect on temperature of adding a simple, partial roof is being studied. Preliminary results suggest that, when loaded wagons are stationary, air temperatures are greater in the partially-roofed wagon, and less when wagons are moving, than in conventional wagons without a roof. These measurements were taken during early winter and spring; further measurements will be made in mid-summer and mid-winter.

Effects of feeding, watering and different marketing procedures

W.R.Shorthose
J.R.Wythes[27]

There was no statistically significant difference in the carcass weights of a group of steers held without access to water or feed, in mild weather, for 24 hours before slaughter and those of a similar group, transported 160 km to slaughter with them, but having access to water on arrival at the meatworks (12 hours on water). However, although the mean water consumption of the group of steers with access to water was only 3.8 litres, the water content of their muscles on a fat-free-wet-weight (FFWW) basis was 0.8% greater than that of muscles of animals not offered water. This difference was significant.

Comparisons were also made of carcass weights and muscle water contents (FFWW) of bullocks transported 1450 km and then subjected to simulated, alternative methods of marketing. Animals transported directly to meatworks and allowed access to water before slaughter had the greatest mean carcass weight, whereas similarly-treated animals not offered water before slaughter had the least mean carcass weight. Bullocks held at the meatworks, on feed (two days) and water (three days), and four groups subject to simulated liveweight selling procedures and killed at the same time as those on feed and water, at the meatworks, had similar mean carcass weights. These were less than the mean carcass weight of animals sent direct to the meatworks and killed after access to water, but greater than that of those sent direct but killed without access to water before slaughter. Differences in muscle water content (FFWW) paralleled carcass weight differences, e.g. a 2% difference between the group with the greatest mean carcass weight and that with the least mean carcass weight.

Effects of pre-slaughter treatment on pig meat quality

G.B.McIntosh[27]
W.R.Shorthose
A.Todd[27]

A survey has been completed of the opinions of managers of Australian meatworks that slaughter pigs on the prevalence of pig deaths in transit to, and at, meatworks and the extent and availability of their records on pig deaths. Work commenced on the collection and analysis of these records from as many meatworks as possible in each State. Initial analyses reinforce previous conclusions that in Queensland highest death rates occur in December, January and February. The annual incidence of deaths is apparently increasing.

Connectin

L.C.Gruen[36]
N.L.King
L.Kurth

Connectin is a myofibrillar protein which is present in skeletal and heart muscle, but not in smooth muscle. During the development of foetal muscle, it appears somewhat later than myosin and actin. Connectin migrates on SDS gels as a band with an apparent molecular weight of 850 000. Light scattering studies of connectin in 6 M guanidine hydrochloride have yielded a slightly higher value (1 000 000) for the sub-unit molecular weight. These measurements were made in the presence of a reducing agent under conditions where any disulphide crosslinks would be broken. However, the high molecular weight and poor solubility of connectin suggest that other crosslinks may be present. In particular, crosslinks initiated by lysyl oxidase have been suggested. In lathyritic muscle, where lysyl oxidase is inhibited, the connectin bands on SDS gels were unaffected. Furthermore, analyses for γ-Glu-ε-Lys have proved negative. There is therefore no evidence for covalent crosslinking in reduced connectin. Because no other protein is known to have a sub unit as large as that of connectin, it may be the longest polypeptide synthesized in nature.

NEW PRODUCTS

Production of pharmaceuticals

I.Griffiths
R.Leppik
R.Park
M.G.Smith

It has been shown that many of the microorganisms isolated from a local abattoir bile treatment plant can grow on cattle and sheep bile and utilize the bile acids. One of these microorganisms, *Pseudomonas* sp. ATCC 31752, was grown on cattle bile aerobically in a fermenter with or without added nutrients, and generated a small number of catabolic products in excellent yield (see Table).

Table

Yields[A] of major neutral products from cattle bile catabolism by *Pseudomonas* sp. ATCC 31752

Metabolite	Actual yield (g) of crude catabolite	Relative yield (%)
7α,12β-Dihydroxyandrosta-1,4-diene-3,17-dione	17.8	79
7α-Hydroxyandrosta-1,4-diene-3,17-dione	0.73	4
12β-Hydroxyandrosta-1,4-diene-3,17-dione	3.05	14
12β-Hydroxyandrosta-4,6-diene-3,17-dione	0.53	2
7α,12β-Dihydroxyandrost-4-ene-3,17-dione	0.37	1

[A]Yield of crude catabolites from fermentation of 100 g of 67% cattle bile solids.

The major product, 7α,12β-dihydroxyandrosta-1,4-diene-3,17-dione, was readily isolated from the fermentation liquor by percolation of the centrifuged liquor through a bed of polymeric Amberlite XAD-2 resin and subsequent elution with methanol-water mixtures. These compounds have potential value as intermediates for the synthesis of steroid drugs. It was subsequently shown that the bile solids concentration of the fermenter charge could be increased to as high as 700 grams per litre, and that growth would still proceed satisfactorily, particularly in the presence of an additional nitrogen source such as ammonium sulphate.

The catabolites listed in the Table were recovered if the growth was terminated when all the bile acid had been utilized, and the ultraviolet absorbance of the fermenter liquor at 240 nm was at its maximum value.

However, if the growth was allowed to proceed slightly beyond this point, the products obtained were different in character and less likely to be useful for steroid drug manufacture. If the growth was terminated before the above point, and bile solids content was very high, another range

of products was obtained, including small amounts of several acidic products.

In contrast, if *Pseudomonas* sp. ATCC 31753 was used for the growth on cattle bile and the growth terminated slightly before the 240 nm absorption maximum of the fermenter liquor, a higher yield of the acidic products was obtained with a smaller yield of the compounds in the Table. 7α,12α-Dihydroxy-3-oxo-pregna-1,4,diene-20-carboxylic acid and related compounds, which have even greater potential value as steroid drug intermediates than the products in the Table, are produced.

The fermentation of pure deoxycholic acid by *Pseudomonas* sp. ATCC 31753 yielded mainly acids, but some neutral compounds were obtained; nine acids, one phenol, and three neutral compounds were identified. A catabolic pathway for bile acids has been proposed for this strain.

MICROBIOLOGY

Gram-positive organisms

The lactic acid bacteria and *Brochothrix thermosphacta* (formerly known as *Microbacterium thermosphactum*) are major components of the psychrotrophic microbial flora of meat stored under anaerobic conditions at 0°-5°C. Studies on the growth and interactions of these organisms have continued with a view to understanding their significance as spoilage organisms of meat.

Carbohydrate metabolism of *B.thermosphacta*

F.H.Grau

As little is known of the metabolic pathways used by *B. thermosphacta* during growth, some investigations of glucose metabolism by this organism have begun. Anaerobically, *B. thermosphacta* appears to catabolize glucose to pyruvate glycolytically. Pyruvate can be further metabolized along three separate pathways to (a) L-lactate, (b) acetate + formate + ethanol, and (c) 2,3-butanediol. The proportions of these end-products formed during anaerobic growth vary. As the pH falls during growth, the production of lactate is increased and the formation of acetate + formate + ethanol is decreased. Small amounts of 2,3-butanediol are formed as the pH falls below 5.5. Acetate and formate appear to exert control over the proportion of pyruvate which is metabolized through the three pathways. The addition of acetate to growing cultures increases the amount of 2,3-butanediol and lactate formed, and reduces the production of ethanol. The addition of both acetate and formate is even more effective in reducing ethanol production, and increasing lactate production. Experiments with C^{14}-acetate show that a considerable proportion of the acetate is metabolized to ethanol and lactate. This is consistent with the organism possessing a reversible pyruvate-formate lyase. The following enzymes, necessary for pyruvate metabolism by the three pathways, have been detected in crude extracts made from anaerobically grown cells: lactic dehydrogenase, ethanol dehydrogenase, acetate kinase, phosphotransacetylase, pH 6 α-acetolactate synthase, and 2,3-butanediol dehydrogenase. The activity of the lactic dehydrogenase is not regulated by fructose-diphosphate. The synthesis of

2,3-butanediol dehydrogenase is induced by acetate and the activity of the pH 6 α-acetolactate synthase is stimulated by acetate.

Control of end-products formed appears to be similar to that in *Escherichia coli* and *Aerobacter aerogenes* in which acetate, and acetate + formate (particularly in the undissociated form), exert control in directing pyruvate metabolism to lactate and/or 2,3-butanediol.

Chemostat growth of *B.thermosphacta*

A.F.Egan
A.Garrett[36]
Judith T.McAvoy
P.J.Rogers[36]

Cultures of *B.thermosphacta* were grown at 25°C in a pH-stat in chemically-defined minimal medium. In the presence of excess glucose, Y_{ATP}^{MAX} (the molar growth yield with respect to ATP corrected for maintenance energy) was 14-15. This compares with a value of 10 previously reported for cultures grown under glucose-limiting conditions. This increase in efficiency observed for cells grown in the pH-stat has been reported for other organisms. In pH-stat cultures the end-products of glucose metabolism were acetate and formate, as well as ethanol and lactate.

Studies on key enzymes of glucose metabolism have commenced. Acetate kinase has been purified to homogeneity; its active form has an approximate molecular weight of 160 000 and is a dimer. Each monomer consists of two polypeptide chains (molecular weight 40 000). The kinetic parameters of the activity of the purified enzyme are being determined.

Lactic acid bacteria

Population changes during storage

A.F.Egan
B.J.Shay

The numbers of lactic acid bacteria found on vacuum-packaged fresh beef increase from less than $100/cm^2$ at the time of packaging to a maximum of 10^7 to $10^8/cm^2$ after about six weeks' storage at 0°C. This number then remains fairly constant during prolonged storage.

Selective plating media were used to show that the types of lactic acid bacteria present change with time, i.e. a dynamic equilibrium exists. Aciduric strains become (more) dominant as storage time is prolonged.

A piece of vacuum-packaged beef was stored at 0°C for twenty-four weeks and sampled for bacteriological analysis at intervals. After each sampling, the meat was re-packed and the pack was flushed with a mixture of nitrogen and carbon dioxide. A mixture of lactobacilli and leuconostocs were present after six weeks' storage. As storage progressed, the population became more homogenous, and after 16 weeks appeared to be dominated by a single species of leuconostoc. Detailed taxonomic studies are being made of the organisms present after varying periods of storage.

Production of hydrogen sulphide

A.F.Egan
B.J.Shay

Studies of the production of hydrogen sulphide by lactobacilli continued. A number of new isolates were obtained from export meat that had been rejected due to greening. The properties of these isolates are being compared to those of strain L13, the one originally identified as responsible for greening of meat of normal pH.

Spoilage of vacuum-packaged fresh beef

S.L.Beilken
A.F.Egan
B.J.Shay

Trials to determine the storage life of vacuum-packaged fresh beef continued. In the absence of contaminating microorganisms, 'sterile' meat spoiled due to the development of an 'off' flavour described by taste-panel members as 'liver-like'. This occurred even when the meat was packaged in bags made of film with a very low oxygen permeability, but the rate of spoilage increased as the film permeability increased. For meat stored at 5°C in bags with a permeability of 25 ml of $O_2/m^2/24h/atm$ (measured at 25°C and 75% RH), the 'off' flavour became significant after 27 days' storage. Thus, even if no spoilage bacteria are present, meat has a limited storage life.

The presence of selected strains of lactic acid bacteria resulted in an increase in the rate of spoilage of meat stored at 5°C. Spoilage was then due mainly to the development of flavour defects described as sour, acid and bitter. Depending upon the strain of bacteria chosen, 'off' flavour became significant 13-28 days after the population reached $10^8/cm^2$. Further studies to determine the rate of spoilage of vacuum-packaged beef at 0°C commenced.

INDUSTRY SECTION

Extension of storage life of lamb carcasses

Vacuum-packaged lamb

B.A.Bill
I.J.Eustace
R.A.Gibbons

Previous results indicated that the storage life of chilled, vacuum-packaged lamb carcasses was extended by treatment of the carcasses with 1.5% w/v acetic acid before packaging. Statistical analysis of data from a more extensive test confirmed the preliminary interpretations.

Effect of residues

B.A.Bill
I.J.Eustace
R.A.Gibbons

Investigations have shown that the test used by West German authorities to detect acetic acid residues on carcasses will give positive results only when meat is treated with acetic acid at concentrations and treatment times far greater than those recommended by MRL.

Microbiological status of offals

B.A.Bill
I.J.Eustace
R.A.Gibbons

The most practicable method for treating beef livers and other offals to reduce numbers of contaminating bacteria is considered to be the immersion of the offals in hot water. Work is in progress to confirm that immersion of beef liver for 10 seconds in water held at 70°-72°C will effect a commercially useful reduction in contamination with *Salmonella*

Mechanically-deboned meat

B.A.Bill
I.J.Eustace
R.A.Gibbons

There have been several instances of meat of poor microbiological quality being recovered from mechanical deboning machines.

Work was undertaken to ascertain how the deboning process affects the microbiological status. Tissue was taken from bones just before they entered the deboning equipment and samples of deboned tissue were taken as it left the pressu

chamber. Analysis of the data indicated no significant difference between bacterial counts on the tissue before and after boning. In addition, pH values were determined. The mean pH of the deboned product was slightly higher than that of tissue trimmed from the bones: 6.4 compared with 6.3.

Vacuum-packaging hot-boned meat

Evaluation of an air ionization system

B.A.Bill
I.J.Eustace
R.A.Gibbons

An air sterilizer, claimed by the manufacturers to operate by generating negative oxygen ions, has recently become available in Australia for use in meat chillers. When operated in a chiller, the system produced ozone in quantities that resulted in concentrations of 0.1 to 0.7 ppm in the chiller air. Past work has indicated that such concentrations are likely to delay significantly the onset of detectable spoilage of meat stored in a chiller.

Vacuum-packaged hot-boned primal cuts

B.A.Bill
I.J.Eustace
R.A.Gibbons

Several packs of beef packed during a hot-boning demonstration at MRL in July 1980 were opened after 14 weeks' storage at 0°C. Appearance of the meat was good, and confinement odour and bacterial counts were similar to conventionally-boned, vacuum-packaged meat stored at the same temperature and for the same time.

Standardized numeric description code

H.M.Chua
B.Y.Johnson
N.G.McPhail

Tests have shown that bar code technology can be used by the meat industry to automate materials and information handling.

The Australian Meat-Numeric Description Working Party was set up in October 1979 as part of an overall effort to encourage the use of bar code technology. In July 1980, a draft Standard on product coding was issued for industry review. The responses received (together with useful comments) were overwhelmingly in favour of the program. A proposed Standard has been prepared and submitted to the Meat Industry Advisory Committee for approval.

Work on the bar code design is continuing at MRL.

Automatic electrical stimulation of beef sides

D.T.Kerr
N.G.McPhail
V.H.Powell

Many abattoirs in Australia do not have sufficient space on the slaughter floor for the installation of a carcass stimulation system, and a system for the automatic stimulation of beef sides is therefore being developed. Results obtained with beef sides stimulated for 45, 60 and 90 seconds with 1100 V (peak) at 30, 45 and 60 minutes respectively after stunning, indicate that stimulation of sides prevents cold-shortening. There is no significant difference in tenderness between meat from unstimulated sides held for 24 hours in 'conditioning' chillers at 15°C, and meat from stimulated sides held at 0°C (air velocity 1-1.5 m/s). Meat from stimulated sides held at 15°C was significantly more tender than the unstimulated sides held at 15°C.

Surface decontamination of beef sides

V.H.Powell

Whilst, visually, there has been definite improvement in hygiene standards over the last 20 years, the limited evidence available indicates that there has not been a corresponding improvement in the microbiological status of meat.

When lamb carcasses were treated with sprays of hot water at 80°C for 10 seconds in a fully-enclosed spray cabinet, 99.9% of contaminating organisms were destroyed without permanently impairing carcass appearance.

A fully-enclosed spray cabinet for the treatment of beef sides was constructed and is being evaluated.

Recovery of meat proteins

R.G.Hamilton

A comprehensive study of the properties of freeze-dewatered myofibrillar proteins was made.

Precipitation of the myofibrillar proteins under severe conditions (with heat, organic solvents, or strong chemicals) produces precipitates in high yield but with substantial loss of functional properties. Denaturation of the sarcoplasmic proteins also results.

The effects of freezing temperature, and pH, and possible interrelationships between these two variables, were studied. The functionality of the freeze-dewatered myofibrillar proteins was determined by instrumental and taste panel evaluation of sausage made with half the meat in the formulation replaced with recovered protein.

Investigations are continuing.

Cost analysis

R.G.Hamilton

A cost analysis of the process of extraction and recovery of meat proteins was prepared for plants of three different sizes. Although the process is capital-intensive, the very low labour input and moderate energy requirement, coupled with the valuable process by-products, contribute to the production of a meat protein concentrate competitive in price with non-meat alternatives.

Placing a unit load of cartons in a shipping container using a 'Sirolift' pallet and a forklift fitted with a pushing attachment

DAIRY RESEARCH LABORATORY

The report of the Committee of Review which examined the role and future of the Dairy Research Laboratory was considered by the CSIRO Executive and the main recommendations endorsed. Mr L.L.Muller was appointed Officer-in-Charge and some changes were made in the research groups to take account of developments and some changes of emphasis in the research program.

Of particular importance during the year was the further development of contract research to bring about the commercial development of processes based on applications of ultrafiltration in cheese-making. The Australian Dairy Corporation had previously entered into an agreement to work jointly with CSIRO on the commercial development of the 'cheese base' project. Following advertisements seeking proposals from interested companies, arrangements were made for a joint R & D project with a large international company involved in the manufacture of processed cheese and in the supply of equipment for cheese processing. This agreement combines the expertise of three organizations and should prove effective in fostering commercial development, with subsequent benefits to the industry in Australia. The project to increase yields in the manufacture of natural cheese by the application of ultrafiltration was accelerated by the appointment of additional staff under the sub-contractual arrangement with the Australian Dairy Corporation. A third research contract provides support from six companies interested in studies on age gelation in UHT milk.

The nature of the agreements on these projects limits the amount of information that can be given in this Report.

STARTER RESEARCH

Plasmid analysis of factory-derived, whey-adapted cheese starters

M.J.Coventry[37]
A.J.Hillier
R.R.Hull
G.R.Jago

Plasmids extracted from cheese starters give a distinctive profile that can be used to identify various strains. A number of phage-resistant derivatives prepared in Australian cheese factories has been analysed by this method. Two classes of derivatives have been detected: (1) Those whose plasmid profile is totally dissimilar to that of the parent strain. This is generally associated with the different reactions of the derivative in biochemical tests (for example, deamination of arginine) and suggests that the 'derivative' may be a contaminant; (2) Those whose plasmid profile is identical with that of the parent. These derivatives are not contaminants and indicate that the acquisition of resistance to phage is not associated with the gain or loss of plasmids. Phage-resistant derivatives that produced body and flavour defects in cheese were analysed and these defects did not appear to be associated with the loss or gain of plasmids.

Carbohydrate metabolism of thermophilic starters

M.J.Coventry[37]
M.W.Hickey[37]
A.J.Hillier
G.R.Jago
Wendy Tinson[37]

While the mechanisms controlling the uptake and hydrolysis of lactose in mesophilic (group N) starter streptococci are well understood, little is known about the carbohydrate metabolism of thermophilic lactic acid bacteria used in the manufacture of cheese at elevated cooking temperatures. The carbohydrate metabolism of strains of *Streptococcus thermophilus*, *S.durans*, *Lactobacillus bulgaricus* and *L.helveticus* have been studied in terms of (1) their preferential utilization of sugars, (2) their sugar uptake mechanisms, and (3) the induction and characterization of catabolic enzyme systems. All the thermophilic organisms tested possessed the enzyme β-galactosidase, but only *S.durans* possessed the phosphoenolpyruvate phosphotransferase system for the uptake of lactose.

Carbon dioxide formation associated with metabolism of S.thermophilus

A.J.Hillier
G.R.Jago
Wendy Tinson[37]

A number of factories using *S.thermophilus* as a starter in the manufacture of cheese have reported 'blowing' of the vacuum-sealed consumer bags. It was shown that all strains of *S.thermophilus* tested (25 in all) produced copious amounts of carbon dioxide when grown in milk. This was due to their ability to hydrolyse the urea present in milk (approximately 5-6 mM) to carbon dioxide and ammonia. The possibility that urea is formed by amino-acid degradation during cheese maturation is also being investigated. A mutant of *S.thermophilus* which does not hydrolyse urea has been isolated and is being studied.

Factory-derived, whey-adapted cheese starters

R.R.Hull
Sonia Toyne

The factory-derived starter system is now used widely for the control of bacteriophage in Cheddar cheese manufacture. However, problems continue to emerge with the operation of this system in industry, and a high priority has been placed on providing assistance to factories experiencing difficulties.

By regular meetings, industry has been kept informed of progress and new developments in this system. Representatives from 14 commercial cheese manufacturers attended a two-day workshop in April 1981.

Further work was aimed at improving the reliability of the cheese starters that are available to industry. Two problems were investigated:

- Stability of phage-resistance of factory-derived starters. Some factory-derived starters have been used continuously in cheese production for long periods without the appearance of disturbing phages. In other factories, however, the stability of derivatives to such phages has been unpredictable. A method which could permit recognition of starters with stable phage-resistance would therefore be of great practical importance.

  Instability can result from a change in the starter itself and this problem has been overcome by freeze-drying derivatives at DRL and returning them in a stable form to the factories.

Instability can also result from a change in the phage population of the cheese factory. A recent investigation of a problem of this type at a large automated factory revealed that a thermophilic culture present in the factory cheese milk was a source of new, disturbing phages.

Fast acid-producing derivatives found to be stable in one factory were introduced into other factories, but without success. However, a number of slow acid-producing derivatives were isolated that exhibit stable phage-resistance in quite a number of factories.

- Improved methods for selection of factory-derived starters. Two problems exist in the selection of phage-resistant derivatives with suitable cheese-making attributes. First, all phage-resistant derivatives isolated from some strains are too slow in lactic acid production to be of use commercially as single strains. Second, some derivatives produce flavour defects in the final cheese.

  Although slow lactic acid-producing strains cannot be used as single strains in Cheddar cheese manufacture, they can be used in conjunction with fast strains as a component of a multiple strain starter.

Use of genetic techniques to improve starter strains

R.R.Hull
I.B.Powell

Genetic recombination through protoplast fusion is being used as a technique for commercial strain improvement in streptococci. An experimental model system in *Streptococcus lactis* was successfully developed. The technique generated recombinants (new genetic types) at a frequency of 1% of the survivors. The properties of the recombinants (including stability during growth) are under study.

Starter cultures

R.R.Hull
Ann V.Roberts

The CSIRO Starter Culture Collection maintains a collection of microorganisms used as starters in the manufacture of cultured dairy products, and new cultures are continually being added. The additions this year include Cheddar starters, mostly in the form of factory-derived, phage-resistant derivatives, yoghurt starters, and starters for the manufacture of fermented milk drinks.

Cultures are prepared in a freeze-dried form and distributed to industry with the assistance of State Departments of Agriculture.

CHEESE TECHNOLOGY

Ultrafiltration (UF) in manufacture of hard cheese

N.H.Freeman
G.W.Jameson
H.J.van Leeuwen
Kim Nguyen-Thi
R.J.Prince

A pilot-scale cheese-making plant was constructed with a designed capacity of 70 kg of the retentate from UF of whole milk. The plant has been tested, modified, and used extensively in cheese-making trials. The main purpose of these trials was to determine the effects of manufacturing variables and certain novel procedures on the body, texture and flavour of the cheese. Some understanding was obtained of the behaviour of starter bacteria in the new cheese-making system, and trials are under way to determine the most suitable maturation conditions for the cheese.

The cheese obtained from the process is an acceptable, hard

Cheddar-type product. However, there is scope for improving its quality.

Pilot-scale cheese-making plant for the manufacture of hard cheese from ultra-filtrated milk

Cheese base for processing

N.H.Freeman
G.W.Jameson
Z.Krapivensky[38]
T.Mounsey
R.M.Shanley
B.J.Sutherland

Work continued on modifications to the evaporator, particularly the product extraction system. Considerable understanding has been gained of factors affecting the evaporation of fermented retentate in this type of equipment. The effects have been observed of milk treatments, UF plant type and other variables on product quality. Process control options have also been investigated.

The size of the yield increase obtainable through the manufacture of cheese base, relative to the yield of Cheddar cheese made from the same milk, has been confirmed. The present trials, using different equipment, again showed yield increases of 16-17%.

FLAVOUR CHEMISTRY

Sensory analysis

I.Barlow

As a first step towards establishing a panel capable of evaluating cheese flavour for comparison with objective evaluations, most of the DRL staff were surveyed for their taste acuity. The majority were able to assess the four basic tastes. The general taste thresholds were: bitter - about 0.03 g/l quinine sulphate, sour - 0.06 g/l citric acid, sweet - below 4.0 g/l sucrose, salt - below 0.4 g/l sodium chloride. Approximately half the panel members (28) could identify one taste in the presence of another at the above threshold levels with the exception that bitterness could be recognized at a much lower level, about 0.008 g/l, in a sour solution. The panel is currently examining a range of cheese samples to establish a vocabulary and evaluate panellist consistency.

As part of a Department of Primary Industry Seminar for Dairy Produce Inspectors, an introduction to sensory analysis was presented.

Milk flavour

W.Stark
Gerda E.Urbach

Studies have begun on the components responsible for the differences in flavour between fresh liquid milk and milk reconstituted from whole milk powder. A panel selected for its ability to distinguish fresh and reconstituted milk differentiated clearly between the dialysates from these milks. Headspace analysis of fresh and reconstituted milk (or their dialysates) showed that the major component was acetone and that the main difference was an increase, about tenfold, in the levels of hydrogen sulphide, carbonyl sulphide, methanethiol and dimethyl sulphide in the reconstituted milk.

The Porapak-based support used previously for headspace analysis was found unsuitable for milk analysis as the large quantities of water caused a significant reduction in retention times. Tenax GC is much less affected by water and proved to be satisfactory for both trapping and separating. Treatment of the Tenax with 1% OV275 resulted in improved chromatographic resolution and reduced tailing compared with treatment with 2% polymetaphenylether.

Analysis of volatile components of cheese

I.Barlow
E.A.Dunstone
J.F.Horwood
G.T.Lloyd
F.H.Ramshaw
W.Stark

Analyses for free fatty acids, sulphur components and headspace volatile components (the last by g.c./monopole m.s.) were performed on some 65 cheese samples collected from commercial factories, analyses being done at one, three and six months of age. It has proved difficult to draw conclusions concerning the relationship of the objective analyses to the subjective grading of the cheeses, as most of the cheeses deteriorated in grade score during storage. The effect of storage on grade score suggests that the storage conditions (at DRL) may not have been typical. A further series of analyses is in progress to test the effect of such factors as block size and storage temperature on the course of the maturation.

Preliminary observations on Cheddar cheese manufactured from the retentate after ultrafiltration of whole milk indicated that flavour development may be slower than normal. The volatile components from such cheese were analysed in an effort to explain this. A low level of diacetyl and acetoin was observed in some cheese initially, and the increase during maturation was slow (the reverse of normal). Normal ethanol and acetic acid levels indicated that the pyruvate dehydrogenase system was functioning satisfactorily Other samples, considered of good flavour, had higher-than-normal levels of butanone, acetic acid and propanol. Such elevated levels are usually associated with adventitious bacteria rather than with starter metabolism. Cheeses made from UF milk reconstituted with permeate had higher levels of volatile components compared with the lower levels obtained from UF milk reconstituted with water.

Off-flavours

Assistance was given to several food manufacturers in an effort to resolve problems caused by off-flavours.

- Three products were found to be tainted with phenolic compounds. It appeared that all had been contaminated after manufacture.
- Commercial cheese with an unclean flavour was found to have high butyric acid levels, presumably caused by lipolysis.

- Commercial cheese with a fermented flavour was shown to have high levels of ethanol, ethyl acetate and ethyl butyrate in the headspace. The fermented flavour was thought to be caused by yeast, the growth of which was favoured by low values for salt-in-moisture.

MILK COMPONENTS

Oxidation in dairy products

P.Roupas
R.E.Timms

Oxidation is a major cause of off-flavour development when dairy foods are stored. Off-flavours can develop at very low levels of oxidation, sensitive methods being required for studies in this field. Current methods, such as peroxide determination, require the fat to be extracted from the dairy food. An alternative technique is being investigated which allows the oxidation of the fat to be studied *in situ*.

During oxidation, many substances, including lipids, emit low levels of light, called chemiluminescence (CL). Using a Packard Tricarb scintillation counter, in 'out of coincidence' mode and controlled at 20°C, measurable CL from milk fat, skim and full cream milk powders, and from liquid milk was observed. Milk powder reconstituted to liquid milk gave out more light than did the dry powder. In all the products studied, CL increased with level of oxidation. There was a close inverse correlation between CL and grade score of reconstituted milk powders as assessed by a taste panel. Preliminary results indicate that the amount of CL from reconstituted skim milk is as great as the CL from full cream milk at the same level of oxidative flavour deterioration.

CL was closely and inversely correlated with the grade score of anhydrous milk fat stored at 50°C and 80°C with and without butylated hydroxy anisole. Fluorescence also increased as CL increased.

N.m.r. studies

R.E.Timms

Lipid/protein interactions in full cream milk powders were studied using a low-resolution, pulsed n.m.r. spectrometer. There was a higher level of lipid/protein interaction in powders made from fresh milk (51-59%) than in powders made from recombined milk (10-45%). The extent of lipid/protein interaction also depended on the order of the various steps used in the recombining process.

The gelation of whey protein concentrate (WPC) solutions could be followed by T_1 or T_2 measurements. Both T_1 and T_2 decreased significantly at gelation. T_1 but not T_2 continued to decrease as the gel aged.

The possibility was studied of using n.m.r. to measure water in dairy products. The water content of concentrated skim milk was highly correlated with the n.m.r. signal in either 90°-180° or 180°-90° pulse modes. However, T_1 and T_2, and therefore the n.m.r. signal, depended on the properties of the milk, especially its composition and preheat treatment. It was concluded that an n.m.r. method cannot be used as a general method for the determination of water

in concentrated milk. Similar results and conclusions were obtained for Cheddar cheese, cheese base and butter.

N.m.r. studies of sweetened condensed milk

B.A.Cornell (FRL)
F.G.Kieseker
R.E.Timms

The viscosity of sweetened condensed milk (SCM) changes during storage. N.m.r. studies using the low-resolution spectrometer did not show any significant differences in T_1 and T_2 with change in viscosity. A single T_2 value of 11-15 m/sec was observed, but the T_1 determination indicated the presence of at least two relaxations. The T_1 relaxation times were studied further using the high resolution n.m.r. spectrometer at FRL. Proton signals for water, sugars and lipid were observed. No signal for protein was observed; it was assumed to lie under the water or lipid signals. T_1 for water and lipid increased over the temperature range 27°-60°C while T_1 for sugars decreased.

Coagulation of heated milk by chymosin

R.Beeby

Heating milk affects its subsequent coagulation by the enzyme chymosin. Heating (85°C for 20 minutes) prolonged the coagulation time, to an extent depending on the pH of the milk. For example, for non-heated and heated samples at pH 7.03, the coagulation times at 30°C were respectively 55 minutes and greater than 6 hours, whereas at pH 6.39 the corresponding times were 5.5 minutes and 7 minutes. At the higher pH, all the κ-casein was cleaved by the enzyme before coagulation took place, while at the lower pH coagulation occurred when approximately 80% of the κ-casein had been split.

Addition to the milk of the carboxyl-activating reagent N-ethoxycarbonyl-2-ethoxyl-1,2-dihydroquinoline (EEDQ) extended the clotting time after addition of chymosin and reduced the rate of firming and syneresis of the curd. The quantity of β-lactoglobulin precipitated with the casein at pH 4.6 or with 2% trichloroacetic acid increased in proportion to the amount of EEDQ added, and the clotting time with chymosin became progressively longer with increasing levels of the reagent. Concomitantly, the casein micelles became resistant to disruption by calcium-sequestering agents, suggesting that crosslinking of the casein components had occurred, possibly by the serum protein. The rate at which κ-casein was cleaved by chymosin was less in the treated milk than in the control, although all the κ-casein appeared to be split eventually. Altering the pH of the treated milk or adding calcium affected the chymosin-induced coagulation properties of the EEDQ-treated milk in a way that was very similar to the response elicited by such procedures in heated milk. The use of this reagent appears to provide a convenient method for obtaining information on some of the changes that occur in milk when it is heated.

Functionality of food proteins

W.J.Harper[39]
R.J.Pearce

Using response-surface methodology, a formulation was derived for a synthetic coffee whitener that responds optimally to small changes in the quantity or characteristics of the protein used. This model food system was used to evaluate the emulsifying ability of proteins.

A quantitative estimation of functional response is a prerequisite for simultaneous evaluation of the interactions of the components in a complex food system. The emulsifying ability of a protein in a coffee whitener can be

estimated by the amount of a buoyant protein/lipid aggregate that is formed, 'feathering', when the whitener is added to hot coffee. A simple test was derived for measurement of the extent of 'feathering'.

Improvement of protein functionality by deamidation

R.J.Pearce

Some functional properties of proteins, for example, whipping and emulsifying abilities, appear to be related to the solubility of the protein in aqueous solution. Attempts elsewhere to increase protein solubility through chemical modification by acetylation or succinylation of lysine residues have been quite successful. However, there is some doubt concerning the biological availability of lysine residues after such modification, and the toxicity of introduced chemical residues is unknown. For these and additional reasons, an alternative method of increasing solubility was sought. Deamidation of the amino-acids, glutamine and asparagine, is being investigated, since the biological value of the modified protein should not be significantly different from the original. Preliminary studies using soybean protein indicated that considerable deamidation could be achieved without hydrolysis of the polypeptide chain. The modification resulted in improved solubility and reduction of the isoelectric point of the protein, as expected. Inclusion in the model coffee whitener formulation and evaluation of the product in hot coffee indicated that progressive deamidation resulted in a corresponding improvement in the emulsion-stabilizing properties of the protein.

A similar study involving the whey proteins, β-lactoglobulin and α-lactalbumin, and WPC, is in progress to optimize conditions for their deamidation.

Allergenicity of milk proteins

B.A.Baldo[40]
R.Beeby
D.J.Hill[41]
A.F.Kemp[42]
R.J.Pearce

Studies were started on milk allergens and immediate hypersensitivity to milk using purified cow's milk proteins and milk protein fractions in crossed immunoelectrophoresis and radioallergosorbent test (RAST) experiments. Examination of proteins from both the whey and casein fractions showed that the caseins were frequently as allergenic as the well-known whey protein allergens, β-lactoglobulin, α-lactalbumin and bovine serum albumin. The milk proteins lend themselves to studies of ingested allergens, as their physical and chemical properties are well characterized. A more detailed study is in progress involving comparative experiments with milk proteins from different species.

Full-cream milk powder for reconstitution

B.Aitken
P.Clarke
D.A.Jones
F.G.Kieseker
W.P.Rogers

Full-cream milk powders were prepared with the required heat stability and viscosity characteristics, respectively, for manufacture into reconstituted evaporated and sweetened condensed milks for comparison with similar products made by recombination. Preliminary results indicate little difference in the organoleptic properties of the two types of product and no major differences in chemical or physical properties.

The dispersion of full-cream milk powder at concentrations of up to 50% total milk solids in water, as required for the preparation of reconstituted sweetened condensed milk, is proving difficult. A study is under way of the effects on reconstitution of powder particle size, powder density, and the level of free fat.

During the manufacture of full-cream milk powder, homogenization is an essential step to control the level of free fat and improve the keeping quality. Trials have shown that variations in homogenization conditions in manufacture of the powder do not overcome the requirement for an additional homogenization treatment during reconstitution to control such aspects as fat separation in evaporated milk or viscosity in sweetened condensed milk. Excessive homogenization during powder manufacture may have an adverse effect on functional properties such as heat stability.

Studies continued on the control of oxidation of full-cream milk powders by the use of natural antioxidants or by manipulation of processing and packing conditions.

The usual high-temperature preheating for the activation of sulphydryl groups is not possible in the manufacture of low- and medium-heat powders. The addition to the milk of unheated and heated WPC is being investigated. The use of unheated WPC had an adverse effect on the heat stability of high-heat powder and on the viscosity of medium-heat powder. Storage trials have been commenced with full-cream powders containing additional naturally-occurring antioxidants, such as δ-tocopherol, β-carotene, citric acid and ascorbyl palmitate.

Trials were started on the use of nitrogen to protect powder against oxidation at all stages of manufacture. Initial results indicate a slight advantage if the final product was packed in air. However, the differences were not marked when the powder is packed under nitrogen.

Maximum protection against oxidation is obtained when full-cream powder is packed under nitrogen in metal containers. However, this is not feasible for the packing of large volumes of powder. Consequently, trials were undertaken to study the effect of decreasing oxygen concentrations in packing bulk milk powder. Results for medium- and high-heat powder held for 40 weeks indicate that the flavour and the peroxide value were somewhat improved when the level of oxygen in the headspace was below 10%.

Microstructure

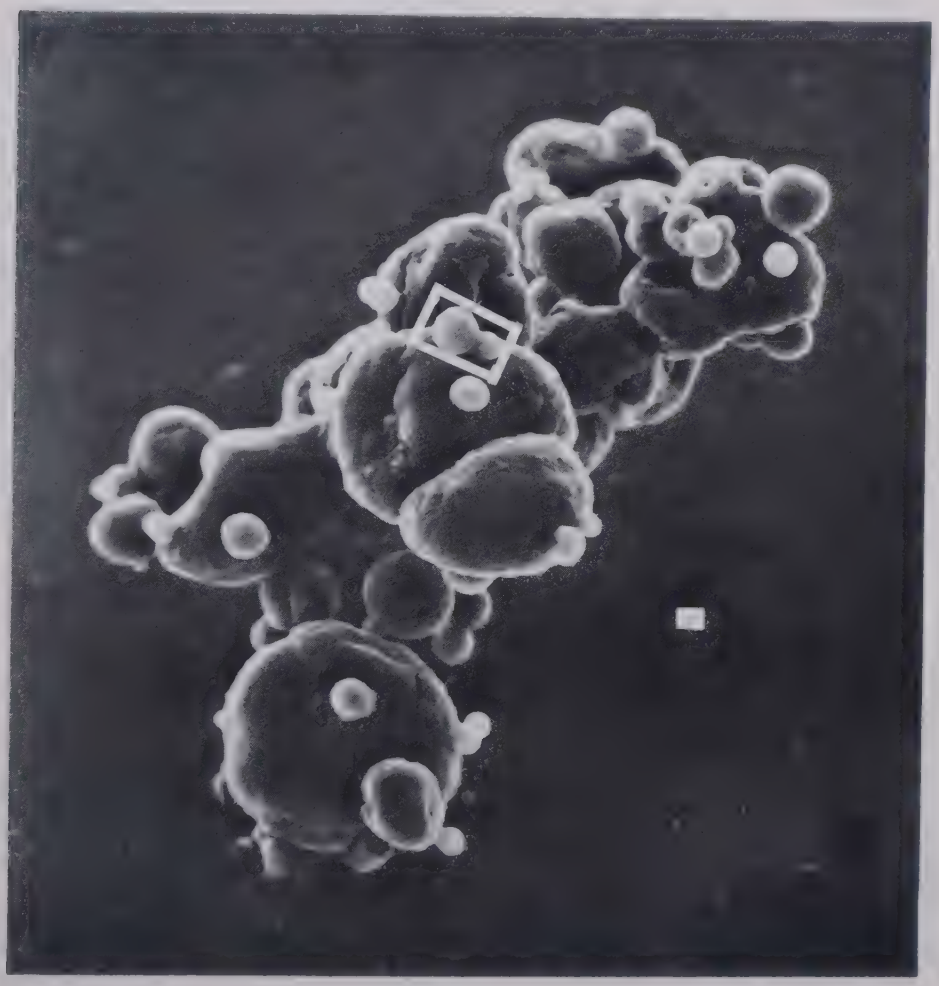
P.D.Shimmin

Skim milk was examined by transmission electron microscopy (TEM) at stages during its conversion to a powder to observe any structural breakdown of the casein micelle in the final product. No breakdown was apparent in laboratory-controlled conditions of preheating to 83°C for 30 minutes and concentrating to 45% total solids. Unstructured casein micelles were observed in factory-produced skim milk powder, but it was not possible to compare the result with the micelle structure in the original skim milk.

Scanning electron microscopy was used to assess the distribution of lactose within the particles of skim milk powder. The lactose appeared to exist in a glass form as a smooth-surfaced sphere.

A method of observing fat distribution within cheese surfaces by incident light fluorescence was developed and is being applied to obtain a better understanding of the granularity of fat and protein complexes. The initial application was to compare Cheddar cheese with cheese base. It

appeared that there was a partial coalescence or clumping of the fat globules within the cheese base, while in the control Cheddar the fat globules were more uniform in size and were evenly distributed.



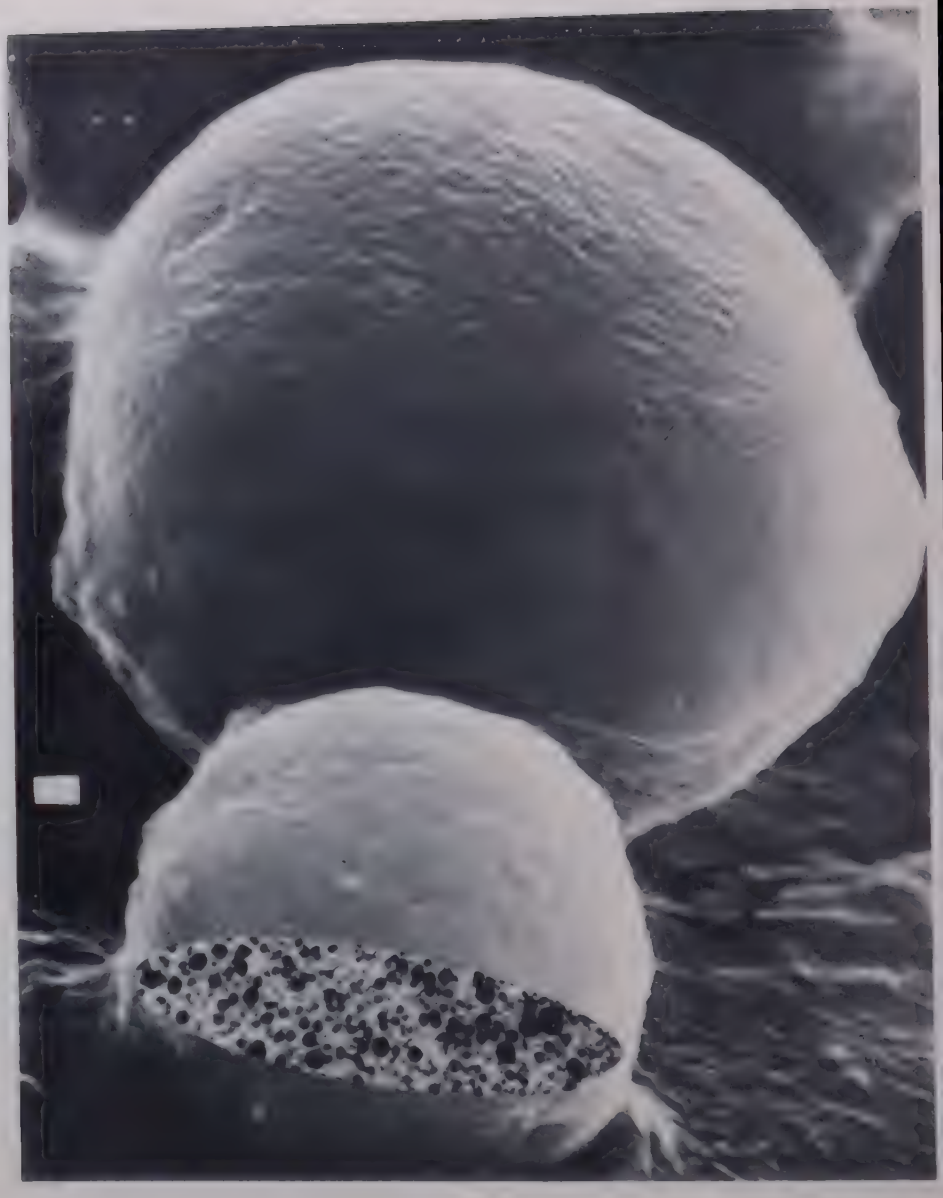
Skim milk powder as seen in a stereoscan electron microscope at a magnification of 2500.
Bar: 5 um

Computing

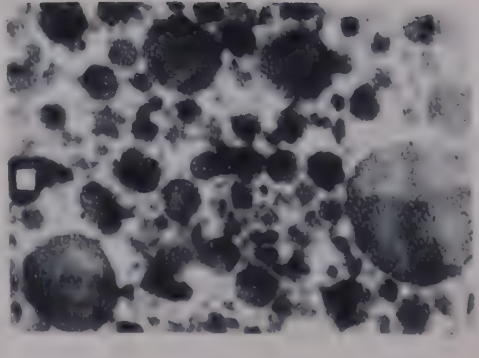
Susan M.Collins
R.E.Timms
J.G.Zadow

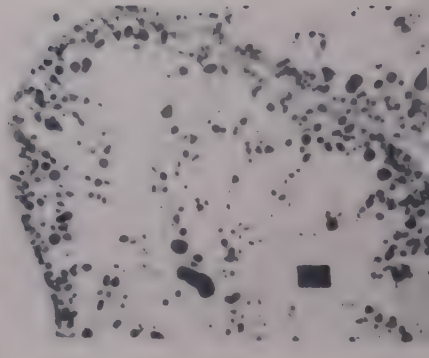
The growing requirement for computing facilities less complex than the CYBER system led to the installation of a microcomputer and the development of software which, for a moderate capital cost and minimal operating costs, meets a high proportion of the needs at DRL.

General purpose programs have been written in BASIC for multiple regression, plotting and analysis of variance. A multi-purpose program called PETRA (Plotting, Editing, Tabulating and Regression Analysis) has also been developed for manipulating x,y data. PETRA is easy to use in a conversational style and requires virtually no knowledge of computing by the user. After regression analysis to determine the best straight line, PETRA determines the statistical significance of the regression constant and coefficient using the t test. The data and the computed regression line may then be plotted if required.



Magnified view (x30 000) of the inset in the previous photograph. The casein micelles can be seen protruding through a periphery in the form of a glass. Transmission electron microscopy of a thin section (x30 000) shows the size and distribution of the casein within the powder particles. Bar: 0.5 µm.





Left: The structure within the casein micelle can be clearly resolved as approximating 9 nm. Bar: 50 nm.
Right: A section through the peripheries of adjacent powder particles having very smooth surfaces. Bar: 0.5 µm

WHEY UTILIZATION

Functional properties of WPC

J.A.Dunkerley
N.Harris
J.F.Hayes
J.G.Zadow

Three UF plants for whey processing have been installed in Australia in the past 12 months. UF allows the production of a range of WPC with specific functional properties as food ingredients. Studies at DRL in collaboration with three overseas research centres aim to increase understanding of the factors influencing WPC functionality.

In further investigations of the factors controlling the strength of gels formed from WPC on heating, WPC from HCl casein whey treated at 80°C/15 s with subsequent adjustment of pH to 5.6 gave gels of high strength at pH 5 and 8. At pH 2, however, gel strength was poor. The addition of EDTA, dithioerythritol (DTE) or cysteine before heat treatment resulted in reduced gel strength at pH 8. Demineralized HCl casein WPC showed maximum gel strength at its natural pH of 7.4. However, the gel strength of this sample was further increased by the addition of calcium, DTE or EDTA. Gels formed from preheated (85°C/15 s) Cheddar WPC showed poor gel strength at the natural pH of 6, with a slight improvement at pH 8, 3 and 2. The addition of EDTA to this sample resulted in an increase in strength at pH 8. With mildly preheated (72°C/15 s) Cheddar WPC, moderate gel strength was obtained at pH 6, 3 and 2, with excellent strength at pH 8. The effects of calcium addition to Cheddar WPC were variable. Demineralized Cheddar WPC formed strong gels at pH 6, with reduced strength at pH 8, 3 and 2. The addition of calcium at pH 8 reduced the strength of this sample. All additive-free samples processed at 72°C/15 s had a gel strength superior to the corresponding samples processed at 85°C/15 s, suggesting that protein denaturation is an important variable. Many factors influence the strength of WPC heat gels and the mechanism involved in their formation is far from understood. However, from studies on the effect on gel strengths of the incorporation of DTE there is evidence that the highly oriented structure typical of a strong gel is at least partly due to disulphide bridge formation.

Lactose-hydrolysed whey products

Corinna E.Hale
N.Harris
J.F.Hayes
S.C.Marshall

Lactose-hydrolysed, whey-based products have potential application for the partial or total replacement of sucrose and/or skim milk solids in products such as ice cream mixes and yoghurt. Research in this area has been concentrated on evaluating differing types of single-use lactases in terms of batch hydrolysis techniques and product functionality. In trials on the hydrolysis of concentrated wheys and concentrated whey/skim milk blends, difficulties were encountered due to coagulation of the product. In the case of the concentrated whey/skim milk blends, residual rennet activity in the whey was a possible factor, while the coagulation of concentrated whey was considered to be the result of precipitation of a calcium phosphate-protein complex. A heat treatment of 85°C for 15 seconds overcame this difficulty for both products. The role of calcium phosphate complexes in the formation of these coagula was highlighted by the coagulation of concentrated (protein-free) UF permeate when held for an extended period at the temperature of hydrolysis (55°C).

Studies were begun on the efficiency of a UF enzyme reactor system. This system has advantages that high enzyme concentrations can be used, resulting in lower reaction times, and that the process cost can be reduced by re-use of the enzyme after recovery by UF. During 30 hours' continuous use of such a system, no loss in enzyme activity was apparent. However, the UF permeation rate decreased over the 30-hour period, probably due to a build-up of a secondary membrane involving calcium phosphate.

Determination of total and reactive sulphydryl and disulphide content of WPC

J.F.Hardham
J.G.Zadow

Evaluation of existing methods for the determination of reactive and total sulphydryl content indicated that none of the published methods are ideal for use with WPC. A method has therefore been developed based on the use of Ellman's reagent. The technique involves a filtration step to remove gross turbidity from the samples and use of a spectrophotometric method to correct for the remaining turbidity. During the course of these trials, some interesting kinetic effects were observed. Samples of WPC which had similar reactive sulphydryl contents when measured after 45 minutes of contact with Ellman's reagent often had widely differing contents when determined after only five minutes' contact. This rate of unfolding and thus the availability of sulphydryl groups appeared to depend, in part, on sample history.

Use of WPC in bread

J.F.Hardham
P.Marston[13]
J.G.Zadow

The reduction in loaf height observed on the incorporation of WPC into bread was shown to be related to the sulphydryl content of the WPC. A linear relationship between loaf score and reactive sulphydryl content of WPC accounted for 82% of the variance in the system. A similar correlation was observed between the total sulphydryl content and loaf score. A satisfactory reduction in sulphydryl content in WPC was achieved by heat treatment alone, or heat treatment in the presence of bromate. Increasing the pH of the WPC during heat treatment greatly reduced the sulphydryl content. However, laboratory methods found to yield WPC of satisfactory baking properties did not always give good results when extended to the pilot scale. In comparing such samples, it was observed that the rates of unfolding of the proteins in aqueous dispersions differed, leading to different rates at which the reactive sulphydryl became available. It is likely that this factor is a major contributor to the observed differences in baking performance of WPC.

In further comparisons of WPC prepared on a pilot or semi-commercial scale, the effect is being examined of the individual steps involved in manufacture of WPC for use in breads. Preliminary results have indicated that pasteurization of the whey, holding time at 55°C and ultrafiltration have only a minor impact on baking characteristics.

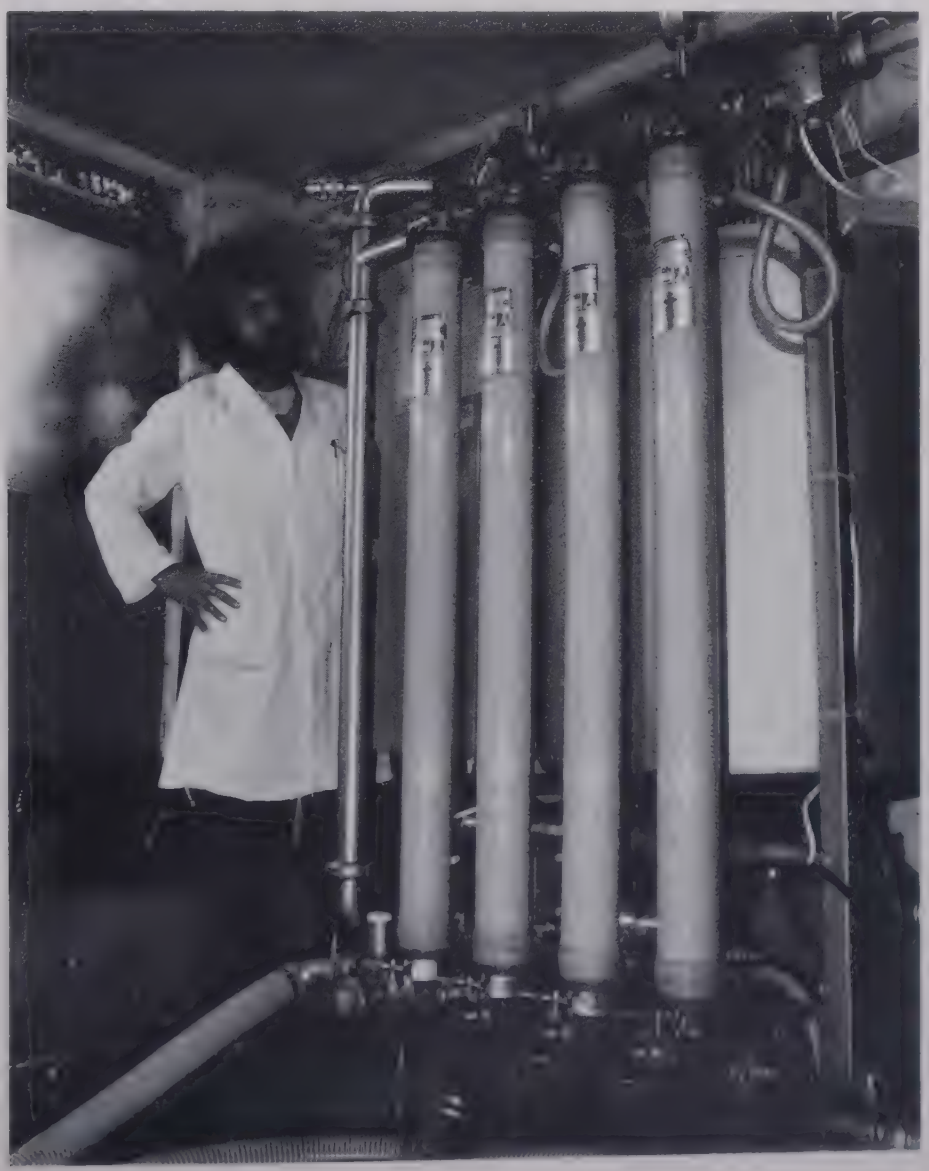
Process inter-relationships

Corinna E.Hale
S.C.Marshall
Robyn A.Smith

As commercial interest in the UF of whey is growing, research effort was concentrated on the evaluation of different UF systems, with particular emphasis on the recently-developed spiral-wound plants. Advantages claimed for spiral-wound equipment include compactness, and energy efficiencies three to four times greater than those of tubular or plate-and-frame systems.

The plants currently under test are:

- Australian Atomic Energy Commission (AAEC) tubular plant. This plant is fitted with cellulose acetate membranes. DRL's results confirm earlier indications that the plant performs similarly to that of Patterson Candy International, giving fluxes of 50 to 55 $1/m^2h$ with high (0.96-0.98) protein rejection and low (0.00-0.06) lactose rejection. Rejections of non-protein nitrogen and various cations were also low. A major redesign is required of the return bends used to connect the modules. At the fluid velocities used, these bends are responsible for about half the pressure drop in the system.



Romicon hollow fibre ultrafiltration plant

- Alfa Laval/Romicon hollow fibre plant. The flux rate achieved with this system for pasteurized Cheddar whey was about 35 $1/m^2h$. Protein rejection values were variable and often as low as 0.93. However, a marked improvement in performance was observed after whey pretreatment at 85°C for 15 seconds. The membranes fitted to the plant were type PM50. A set of 'tighter'

PM10 membranes will be evaluated in the near future. Energy efficiency for this plant was similar to that of the spiral-wound systems described below.

- Ladish Tri Clover (LTC) spiral-wound. Fluxes of about 70 l/m^2h on pasteurized Cheddar cheese whey were observed, with protein rejection values of around 0.96. However, pretreatment of whey at 85°C for 15 seconds did not affect flux, probably due to the low fluid velocity in this system.

- Abcor spiral-wound. Work on this plant is at an early stage, but results so far show that performance appears to be similar to that of the LTC plant, except that some response to an 85°C/15 second pretreatment was observed.

- Ultrapore Pty Ltd 'Spiral Wrap'. Work on this plant is also at an early stage. Performance appears to be similar to that of the other two spiral types examined.

Studies on ultra-high-temperature (UHT) processing of dairy products

J.F.Hardham
H.R.Kocak
J.G.Zadow

The recent upsurge in interest in UHT processing within Australia, with eight plants now on stream, has resulted in a strong demand by processing companies for assistance in the development of formulated UHT products, using the DRL pilot-scale plant. Two schools were held to train the technical staff of the companies in the operation of the pilot plant. The success of these schools can be gauged by the fact that industry staff have now carried out more than 30 trials on this unit.

Research into the cause and control of age gelation in UHT milks has been funded by a group of six companies with interests in UHT production. The aim of the project is to evaluate the practical applicability of the low-temperature-inactivation (LTI) process for the control of this defect. The action of proteolytic enzymes in the milk is considered to lead to the onset of age gelation, and the technique relies on a specific heat treatment to reduce their activity. The first phase of this investigation has been completed. A major part of the work has involved a detailed study of the effect of storage temperature on age gelation, and the relation between proteolytic activity and storage temperature.

When goat's milk is subjected to UHT processing, extensive sediment forms rapidly in the product and is visually evident after less than one hour of storage. The sediment is composed of portion of the casein and the denatured whey proteins of the milk. The formation of this sediment was overcome by adjustment of the pH of the milk to approximately 7.0 or by the addition of di-sodium hydrogen phosphate. This instability is similar to that observed with cow's milk but occurs at a substantially higher pH. Studies on the composition of goat's milk have indicated that it has a higher ionic calcium content than does cow's milk at a given pH. For both milks, a two- to three-fold increase was observed in the ionic calcium content on changing the pH from 6.9 to 6.6. A decrease in ionic calcium occurred when the products were sterilized. Ionic calcium has been implicated in the instability of milks to UHT processing.

Activity of psychrotrophic bacteria in milk

Barbara P.Keogh
G.Pettingill

As the enzymes of psychrotrophic bacteria are known to be important in the age gelation of UHT milk, a rapid and simple test to determine the order of psychrotrophic activity would be of considerable value in the selection and screening of milks for UHT manufacture. Studies have been in progress to develop such a test based on harvesting the bacterial cells from milk samples and measuring the activity of their proteolytic enzymes. Statistical analysis of preliminary results showed a linear relationship between the fluorescence measurement of proteolytic activity and the log psychrotrophic count. However, when milk from other districts and milk collected at other times of the year were tested, the relationship was not as good. This appeared to be due to variation in the dominance of different bacterial species. Tests are under way to investigate the relationship of the proteolytic activity of the harvested cells to the age gelation of UHT processed milk.

Methods for assay of bacteriophage of lactic streptococci

Barbara P.Keogh
G.Pettingill

To assess the relative merits of tryptone yeast extract agar (TYA), TYA unbuffered, and medium M17 for the assay of nine bacteriophages of lactic streptococci, comparative plaque counts were made with an overlay of either 3 or 9 ml on a standard petri dish. Four of the phages exhibited no significant difference in plating efficiency between media. The effect of overlay volume varied from strain to strain and was different for different media. The 3-ml overlay created sub-optimal atmospheric conditions for those strains with a special requirement for CO_2. The use of a 9-ml overlay obviated the need to incubate plates under CO_2 and overcame the problems related to special calcium requirements when TYA was used. The organic buffer (disodium β-glycerophosphate) was inhibitory to *Streptococcus cremoris* ML1 and showed no advantage over the inorganic phosphate buffer (K_2HPO_4) for most other strains.

Aberrant forms of Streptococcus cremoris HP

Barbara P.Keogh
J.E.Peterson[11]
G.Pettingill

The cheese starter strain, *S.cremoris* HP, produced variant colonies when streaked on the surface of solid media and incubated at either 30°C or 37°C, or at 25°C in the presence of penicillin. Serial plating and incubation at 37°C, or at 25°C in the presence of penicillin, resulted in the production of variants. Sub-culture followed by incubation at 25°C or in the absence of penicillin resulted in reversion or partial reversion to the parent form. Colonial morphology and cell morphology exhibited the characteristics of the L-phase. Evidence suggested that the aberrant forms of *S.cremoris* at 30°C were transitional phase variants but at 37°C and in the presence of penicillin they were L-phase variants. Electromicrographs showed that the cell walls of the variant cells were defective and that there were differences in the density and the organization of the cytoplasmic constituents compared with the parent cell.

MATHEMATICS AND STATISTICS IN THE DIVISION

Advice is given by mathematicians and statisticians resident at the Division's main Laboratories on a variety of mathematical, statistical and computer techniques. Some of the areas where expertise is available are:

R.I.Baxter[6]
D.J.Best[6]
Susan Clancy[6]
Elaine J.Smith[6]
Mary E.Willcox[6]

At FRL -

- Sampling schemes for use in standards.
- Design of experiments in order to get maximum information with a minimum of effort.
- Numerical analysis.
- Multivariate analysis, particularly in sensory evaluation.
- Use of computers for graphics, modelling and analysing experimental results.

One recent project in which statisticians were involved was in helping to define the limits to the consumer acceptability of grapefruit juice in terms of certain chemically determined criteria. Average taste-test scores for the flavour of 28 commercial grapefruit juices were obtained. Chemical assays on these same 28 juices were made to determine such quantities as percentage acid, the brix/acid ratio, percentage limonin and percentage naringin. These chemical responses were then used as predictor variables and a computer search made to find the linear combination of predictor variables that best predicted grapefruit flavour.

P.N.Jones[6]

At MRL -

- Variation in fat cell size distributions of omental, perirenal and subcutaneous tissues of sheep during growth.
- Comparison between two Warner-Bratzler shear systems used for measuring meat tenderness.
- Analysis of effects of using curare with electrical stimulation to study stimulation pathways in sheep carcasses.

Affiliation of collaborating workers

[1]Howden Refrigeration Pty Ltd, Sydney, NSW

[2]Macquarie University, Sydney, NSW

[3]University of Paris, France

[4]Department of Primary Industry, Papua New Guinea

[5]NSW Department of Agriculture

[6]CSIRO Division of Mathematics and Statistics

[7]Health Commission of NSW

[8]Pennsylvania Muscle Institute, University of Pennsylvania, USA

[9]CSIRO Division of Computing Research

[10]Australian National University, Canberra, ACT

[11]CSIRO Division of Animal Health

[12]University of Cambridge, UK

[13]Bread Research Institute of Australia

[14]CSIRO Division of Human Nutrition

[15]The City University of New York, USA

[16]La Trobe University, Melbourne, Victoria

[17]Australian Atomic Energy Commission, Lucas Heights, NSW

[18]Agriculture Canada, Ottawa, Canada

[19]CSIRO Division of Applied Organic Chemistry

[20]DSIR, Palmerston North, New Zealand

[21]Carlsberg Research Center, Copenhagen, Denmark

[22]University of New England, Armidale, NSW

[23]Tasmanian Department of Agriculture

[24]University of New South Wales, Sydney, NSW

[25]Thailand Institute of Scientific and Technological Research

[26]University of Osaka Prefecture, Osaka, Japan

[27]Queensland Department of Primary Industries

[28]University of Tasmania, Hobart, Tasmania

[29]Ministry of Overseas Development, UK

[30]Ministry of Agriculture, Fisheries and Food, UK

[31]Department of Science and Technology, Queensland

[32]K.Visser and Associates Pty Ltd, Queensland

[33]Mie University, Japan

[34]Northern Territory Department of Primary Production

[35]Queensland Meat Industry Organization and Marketing Authority

[36]Griffith University, Nathan, Queensland

[37]University of Melbourne, Victoria

[38]Australian Dairy Corporation

[39]Ohio State University, USA

[40]Roche Research Institute of Marine Pharmacology, Dee Why, NSW

[41]Royal Children's Hospital, Parkville, Victoria

[42]Royal Alexandra Hospital for Children, Camperdown, NSW

COMMITTEES

Members of the Division serve on a variety of committees, on some in an official capacity as officers of CSIRO, and on others because of their professional interests and expertise.

The following list makes no attempt at completeness, but is indicative of the wide representation provided by members of staff in the general field of food research.

Academic Press - Monograph Series - Editorial Board
Advances in Food Research - Editorial Board
American Society for Testing Materials - Committee E18
  Sensory Evaluation
ASEAN (Projects on Fruits and Vegetables, Postharvest) -
  Advisory Committee
ANZAAS -
  Council
  Organizing Committee 52nd Congress
Australian Academy of Science - National Committee for
  Nutritional Sciences
Australian Apple and Pear Corporation - Processing Committee
Australian Chicken Meat Research Committee and its Research
  Advisory Panel
Australian Codex Panels on -
  Fats and Oils
  Fish and Fishery Products
  Food Hygiene
  Food Labelling
  Processed Fruit and Vegetables
  Processed Meat and Poultry Products
  Quick Frozen Foods
Australian Consumers Association - Consumer Education and
  Product Testing
Australian Dairy Corporation - Development Committees for
  Cheese, Butter, and Milk Powder
Australian Dairy Products Standards Organization -
  Working Party
  Microbiology Sub-Committee
Australian Defence Forces Food Specification Committee
Australian Institute of Food Science and Technology -
  Council, Branch and Group Committees
Australian Institute of Physics - Science Policy Committee
Australian Meat and Live-stock Corporation - Sub-Committee
  on Carton Marking
Australian Meat Research Committee, and its
  Meat Research Advisory Panel
  Industry Section Liaison Sub-Committee
Australian National Committee of IDF
Australian Nutrition Foundation -
  Council
  NSW Division
Australian Society of Dairy Technology -
  Federal Executive
  Victorian Divisional Executive
  Publications Committee
Australian Society for Microbiology Inc. -
  National and Branch Committees
  Sub-Committee Qualifications
Bread Research Institute of Australia - Council

Chemical Senses - Editorial Board
Consumer Education Freezing of Foods Council (NSW)
Council of Australian Food Technology Associations -
  Food Legislation Committee
  Education Sub-Committee
  Journal Advisory Committee
Dairy Manufacturing Research Sub-Committee
Department of Primary Industry -
  Dairying Research Committee
  Dried Fruits Research Committee
  Fishing Industry Research Committee
  Honey Research Advisory Committee
  Meat Industry Advisory Committee, and its
    Technical Sub-Committee on Petfood
    Technical Sub-Committee on Edible Protein Residue
    Numeric Code Working Party
  DPI-BMCA-CSIRO Committee on Meat Canning Regulations
  National Coordinating Committees -
    Heavy Metals in Seafoods
    Metals in Fish and Fish Products
Dried Fruits Processing Liaison Sub-Committee
Egyptian Journal of Dairy Science - Advisory Board
European Chemo-Reception Research Organization - Editorial Board
European Meat Research Workers Conference
Food Chemistry - Editorial Board
Gilbert Chandler Institute of Dairy Technology - Advisory Council
Gosford Horticultural Postharvest Laboratory - Research Advisory Committee
Hawkesbury Agricultural College of Advanced Education -
  Council, and its Education & Forward Planning Committee
  School of Food Sciences Advisory Board
  Course Assessment Committee (NSW Higher Education Board)
Indo-Pacific Fishery Commission Working Party on Fish Technology and Marketing
Industrial R & D Incentives Act, 1976 -
  Section 39 Steering Committee
  Plate Freezing of Meat
Institution of Chemical Engineers, Queensland Branch -
  Executive Committee
International Association of Microbiological Societies -
  International Committee on Food Microbiology and Food Hygiene
  Sub-Committee on the Taxonomy of the Genus *Bacillus*
International Botanical Congress 1981 -
  Sydney Committee
  Section Committees for Developmental Botany and Metabolic Botany
  Committees for -
    Metabolic Botany
    Industrial Exhibits
    Environmental Botany
International Commission on Microbiological Specifications for Foods
International Conference on the Biochemistry of Lipids -
  Steering Committee
International Dairy Federation and its Specialist Groups
International Frozen Food Association - Scientific and Technical Advisory Group

International Institute of Refrigeration -
  Australian National Committee
  Commission C1 Freeze Drying
  Commission C2 Food Science and Technology
  Commission D2 Refrigerated Land Transport
  Thermophysical Properties of Foodstuffs Working Party Committee
International Union of Food Science and Technology, and its Working Group on the Influence of Smoking and Drying on the Nutritional and Functional Properties of Fish
International Union of Nutritional Sciences - Commission on Microbiology and Nutrition of Animals
International Union of Pure and Applied Chemistry - Commission on Fats and Oils
Joint FAO/WHO Consultation on Microbiological Specifications for Foods
Journal of Chromatography (Biomedical Applications) - Editorial Board
Journal of Food Biochemistry - Editorial Board
Journal of Texture Studies - Editorial Board
Macquarie University -
  Schools Committee, School of Biological Sciences
  Honours Committee
  Biosafety Committee
Meat and Allied Trades Advisory Committee on Technical Education
Meat Science - Editorial Board
National Association of Testing Authorities (Assessors)
National Cattle Symposium - Organizing Committee
National Health and Medical Research Council -
  Food Standards (Standing) Committee
  (Reference) Sub-Committees for Food Microbiology and Food Science and Technology
  Working Parties on -
    Food Composition Data
    Standards for Cheese
    Liquid Milk and Milk Products
    Standards for Special Dietary Food
National Peanut Council of Australia - Technical Committee
NSW Department of Technical and Further Education -
  Food Technology Advisory Committee
  Food Technology Certificate Course Advisory Committee
  Hotel and Catering Trade Course Advisory Committee
NSW Institute of Technology - Course Advisory Committee of School of Life Sciences
Noxious Microbes Act Review Committee, NSW
Nutrition Society of Australia - Council, and Sydney Group
Poultry Research Advisory Committee
Queensland Agricultural Collete - Food Technology Courses Advisory Committee
Queensland Board of Advanced Education - Tertiary Course Assessment Committee
Queensland Institute of Technology -
  Graduate Studies Standing Committee, School of Applied Science
  Applied Physics Course Advisory Committee
  Chemistry Course Advisory Committee
Royal Australian Chemical Institute -
  Queensland Branch Committee
  Polymer Group

Royal Melbourne Institute of Technology - Department of Applied Chemistry, Course Advisory Committee on Food Science and Technology
Standards Association of Australia - Committees and Sub-Committees dealing with:
- Dairying Standards Board
- Methods for Sampling of Milk and Dairy Products
- Microbiological Methods for Examination of Dairy Products and for Dairy Purposes
- Characterization of Dried Milk according to Heat Treatment and Usage
- Rennets
- Detergents and Sanitizers used by the Food, Dairy and Meat Industries
- Egg and Egg Products
- Essential Oils
- Frozen Food Retail Cabinets
- ISO Standards for Foods
- Microbiological Evaluation of Food
- Microbiological Examination of Foods
- Assessment of Odour from Food Packaging Materials
- Plastics for Food Contact
- Sensory Evaluation of Foods
- Thermal Mass of Frozen Seafoods
- Thermal Processing Equipment for Canned Foods
- Double Seams for Metal Cans
- Tinplate and Blackplate

Standing Committee on Agriculture -
- Entomology Committee - Container Disinfestation Working Party
- Sub-Committee on Fresh Fruit Disinfestation and Fruit and Vegetable Postharvest Research
- Technical Sub-Committee - Poultry Production

Tasmanian Department of the Environment - Marine Dumping Sub-Committee
Tasmanian Health Department -
- Working Party on Metals in Seafoods
- Food Standards Committee

TRIPOD - Working Party on Food
University of New South Wales - Visiting Committee for School of Food Technology
University of Sydney - Board of Studies for Diploma in Nutrition and Dietetics
WHO Expert Advisory Panel on Microbiological Aspects of Food Hygiene

PUBLICATIONS

*Indicates that author is not a member of the Division.

†Indicates that author is not a member of the Division but is stationed permanently at a Divisional Laboratory.

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PATENTS

At 30 June 1981, the Division had 45 completed patents in force, 8 in Australia and 37 overseas. There were 15 patent applications pending, 3 in Australia and 12 overseas.

Patents are listed below in chronological order, with the year of the Australian application in brackets.

CZULAK, J. (1959). Apparatus for adding in controlled proportions. Canadian Pat. 734 159. Licensed to Bell Bryant Pty Ltd.

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CZULAK, J. (1967). Draining and processing of curd in the manufacture of cheese. U.S. Pat. 3 523 367, Canadian Pat. 873 809. Licensed to Bell Bryant Pty Ltd.

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CZULAK, J., and SUTHERLAND, B.J. (1971). Semi-continuous cheese-making process machine. Canadian Pat. 979 274.

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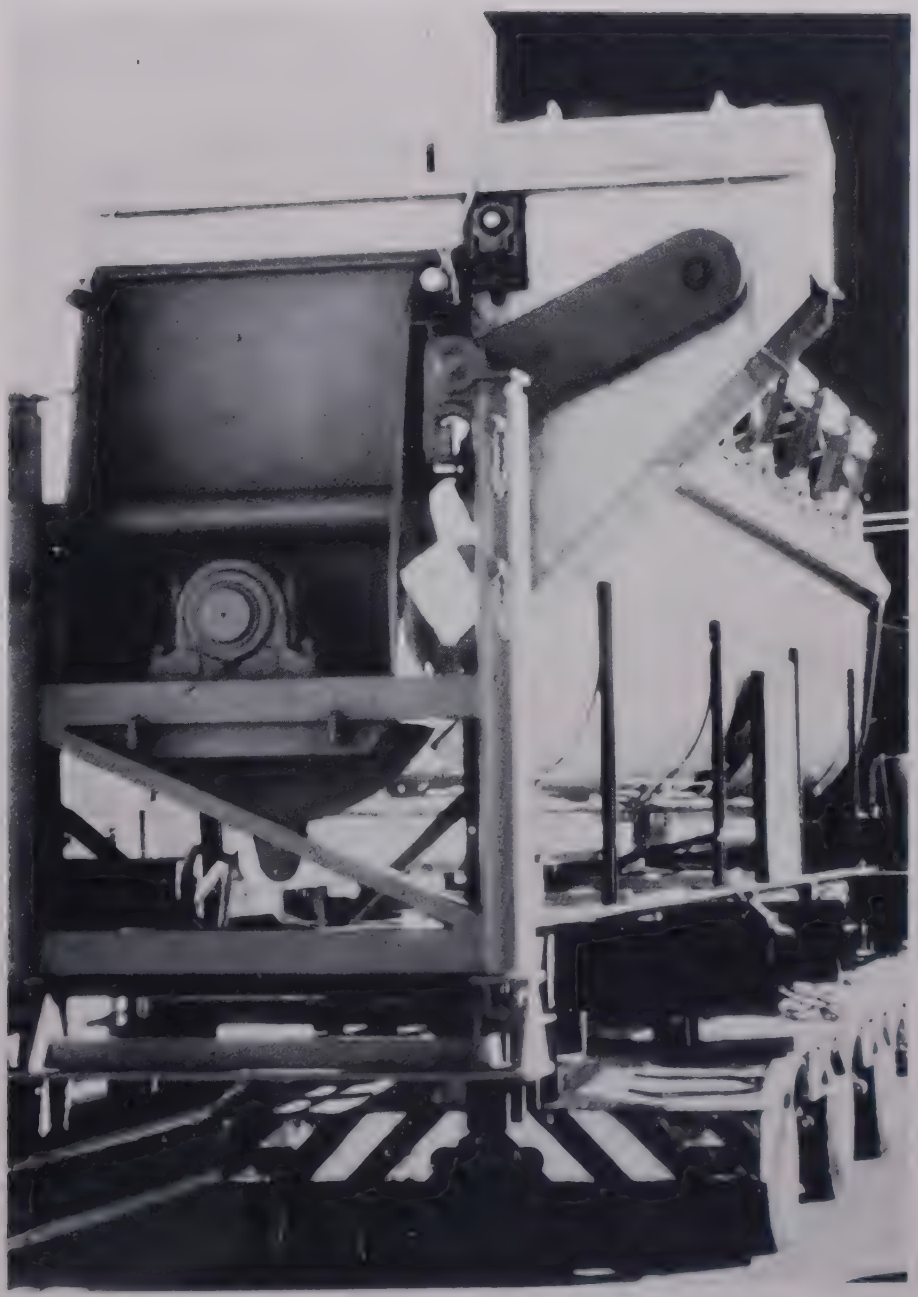
KIESEKER, F.G., and ZADOW, J.G. (1975). Cream powder. Austr lian Pat. 500 153. Also Patent of Addition pending. License to Murray Goulburn Co-operative Co.Ltd.

New patents pending:

PARK, R.J., and LEPPIK, R.A. (1980). Fermentation of bile. Australia, Canada, New Zealand.

HOLLAND, R.V., ROONEY, M.L., and BOARD, P.W. (1980). Measuri oxygen permeabilities of polymer films. Australia.

CASIMIR, D.J. (1980). Reversing diffusion extractor. Austral Canada, USA.



Australian-made counter current extractor, designed for apple juice extraction (5 tonnes/h), being unloaded at Nelson, N.Z.

INDUSTRY AND CONSUMER LIAISON

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Assistant Chief (External Relations)	J.F.Kefford,MSc,FAIFST

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Meat Research Laboratory (MRL)

Publications/Liaison Officer	S.C.Williams,MSc,MBA
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" " (Melbourne)	D.R.Smith,ARMIT
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North Ryde, NSW

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Administrative Officer	R.D.Lipscomb,BSc (overseas) M.T.Turner,BA (Acting)
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Senior Technical Officer (Assistant to Engineer)	G.B.Morgan
Senior Technical Officer (Photographer)	W.E.Rushton
Librarian	I.A.Mathieson,BSc,BE,GradDipLibSc
Library Officers	Mrs J.M.Lawson,ALAA Mrs J.H.Maddalena,ALAA*
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Technical Assistants	R.J.Coghlan*
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	F.B.Whitfield,MSc,ASTC,PhD
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	D.G.Laing,BSc,PhD
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	D.Gallimore
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	G.S.Sidhu,BScAgr,PhD
	A.D.Warth,MSc,PhD
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	G.L.Ford,BA
	P.G.Gwatkin,BSc
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	Miss A.D.Hocking,BSc
	J.A.Lindsay,BSc,PhD
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	N.F.B.Tobin,BSc
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Technical Officers	R.L.Jones,BApplSc
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Principal Research Scientists	J.B.Davenport,MSc
	D.G.Oakenfull,MSc,PhD
	N.S.Parker,BSc,PhD
	M.B.Smith,DSc,ASASM
Senior Research Scientists	B.A.Cornell,BSc,PhD
	L.R.Fisher,MSc,PhD
Experimental Officers	Miss J.F.Back,BSc,DipEd
	M.A.Brown,MSc,DipTech(Sci)
	Miss D.E.Fenwick,ASTC
	G.W.Francis,MSc
	B.H.Kennett,ASTC
	Mrs T.H.L.Nguyen,BSc
	F.S.Shenstone,ASTC
	R.W.Sleigh,MSc
Senior Technical Officers	R.A.Gamble
	W.C.Osborne
	A.G.Scott
Technical Officer	Miss F.E.Separovic
Technical Assistant	Miss L.E.Weir*

Electronics

Technical Assistant	R.A.Pearson

Plant Physiology

(†Located at Macquarie University)

Chief Research Scientist	R.M.Smillie,MSc,PhD,DSc
Senior Principal Research Scientists	D.Graham,BSc,PhD (Research Leader)
	W.B.McGlasson,BAgSc,PhD
	J.K.Raison,BSc,PhD†
Principal Research Scientists	Miss J.M.Bain,MSc,PhD
	D.G.Bishop,MSc,PhD†
	C.J.Brady,MScAgr,PhD†
	B.D.Patterson,BSc,PhD
Senior Research Scientist	J.Speirs,MSc,PhD†
Experimental Officers	G.R.Chaplin,BScAgr,MSc
	Miss S.E.Hetherington,BSc
	D.G.Hockley,BSc
	P.B.H.O'Connell,MSc†
	Mrs J.A.Pearson,MSc
	Miss P.J.Walcott,BSc†
	Mrs L.C.Wright,MSc†
Senior Technical Officers	W.McC.Bailey
	Mrs J.R.Kenrick,AIMT†
Technical Officers	J.Boss
	Miss E.Lee,BA†
	Miss R.S.Nott
	Mrs L.A.Payne
Technical Assistants	Miss J.M.Giugni,BSc*
	Miss G.R.Orr†*
Assistant (Laboratory Services)	Miss C.A.Lee* (At Gosford, NSW)
Senior Laboratory Craftsmen	W.J.New
	M.Schenk
Steno-secretary	Mrs V.M.Petro†

Tasmanian Food Research Unit (at Hobart, Tas.)

Senior Principal Research Scientist	Miss J.Olley,PhD,DSc,FAIFST,FIFST,FTS (Research Leader)
Experimental Officers	H.A.Bremner,MSc,ARMIT
	A.R.Quarmby,AAIFST
	Miss J.A.Statham,BAgrSc*
	S.J.Sykes,BEng*
	S.J.Thrower,MSc,DipEd
Technical Officers	L.B.Barker
	A.M.A.Vail
Technical Assistants	Miss H.Attwood§
	P.S.Kearney*
	Miss M.L.Ottenschlaeger*

Workshops

Senior Technical Officer (Glassblower)	D.C.Rose
Technical Officer	A.G.R.Clark (Workshop Supervisor)
Senior Laboratory Craftsman	R.J.Allen (Leading Hand)
	G.Calvi
	R.Jones
	N.A.Leyer
	G.D.Truelove
Laboratory Craftsmen	E.H.Goldsmith*
	K.A.Luff
Apprentices	B.Le Breton
	B.J.Mann
	D.Medlin
Handyman	R.Gallo

Administration

Administrative Officer	Mrs B.Bussell,BApSc (Acting)
Clerk	Miss H.M.Willetts*
Clerical Assistants	Mrs J.A.Haven
	Miss P.A.Milton*
	G.A.Moore
	Miss V.Nolan
	Mrs T.M.Thompson
	Mrs J.Willcox
Typist Supervisor	Miss P.A.Benson
Typist	Mrs D.J.Williams*
Senior Stores Supervisor	R.C.Declauzel
Assistant (Food Services)	Mrs M.Coyle
Assistant (Transport)	R.J.Aspery
Handyman	B.J.Rayner
Caretaker	H.Hayes

Meat Research Laboratory (MRL) Cannon Hill, Qld.

Officer-in-Charge and Assistant Chief	D.J.Walker,BSc,PhD,DSc,FAIFST
Administrative Officer	M.J.Lilley

Scientific Services

Scientific Services Officer (Publications/Liaison)	S.C.Williams,MSc,MBA
Library	Miss E.E.Dickason,BSc,DipEd,DipLib
Library Officer	Mrs J.E.Gould,ALAA

Muscle Growth and Development

Principal Research Scientists	D.J.Morton,BSc,PhD
	R.W.D.Rowe,BSc,PhD
Senior Research Scientist	D.J.Horgan,BSc,BEcon,PhD
Experimental Officers	F.D.Shaw,BSc,MVSc
	J.F.Weidemann,BSc
Technical Officers	Miss S.Dyson
	R.Kuypers

Meat Science and Technology

Senior Principal Research Scientists	J.J.Macfarlane,MSc,FRACI,FAIFST
	P.V.Harris,BSc,PhD
Principal Research Scientist	W.R.Shorthose,BSc,PhD
Senior Research Scientist	N.L.King,BSc,PhD
Experimental Officers	P.E.Bouton,BSc
	I.J.McKenzie,BAppSci
Senior Technical Officer	R.H.Turner
Technical Officers	R.F.Dickinson
	L.B.Kurth,BAppSci
Technical Assistants	S.L.Beilken
	Miss S.Kamarinos*

New Products

Principal Research Scientist	R.J.Park,MSc,PhD,FRACI
Experimental Officer	R.A.Leppik,MSc,PhD
Technical Officer	I.Griffiths

Process Engineering

Principal Research Scientist	L.S.Herbert,BSc
Research Scientist	K.R.Davey,BChemEng,MEngSc,PhD
Experimental Officers	D.T.Kerr,DipMechEng
	D.A.Lovett,BSc
	S.M.Travers,BAppSc
Senior Technical Officers	R.W.Tritchler
	G.L.Wescombe
Technical Officers	J.Anderson
	W.K.Larnach

Biochemistry

Senior Principal Research Scientist	R.P.Newbold,MSc,PhD
Principal Research Scientist	R.F.Thornton,BSc,PhD
Senior Research Scientist	R.K.Tume,BSc,PhD
Experimental Officer	Miss H.C.Morton,BSc
Senior Technical Officer	T.W.Larsen,BAppSci
Technical Officers	B.W.Arantz
	G.W.Johnson

Microbiology

Principal Research Scientists	A.F.Egan,MSc,PhD
	F.H.Grau,MSc,PhD
Experimental Officer	M.G.Smith,BSc
Senior Technical Officer	B.J.Shay
Technical Assistants	G.M.Higgs,BAppSci
	P.B.Vanderlinde

Industry	
Senior Research Scientist	V.H.Powell,MSc,PhD
Experimental Officers	J.W.Buhot,BEng*
	H.M.Chua,BEng,MBA
	I.J.Eustace,BAgSci
	R.G.Hamilton,BAppSci
Scientific Services Officers	
(Information)	B.Y.Johnson,BAgSci
(Extension)	P.M.Husband,BAppSci (Perth, WA)
	D.R.Smith,ARMIT (Melbourne, Vic.)
	W.F.Spooncer,BSc (Sydney, NSW)
Technical Officers	B.A.Bill
	B.Cain
	N.G.McPhail
Technical Assistants	R.A.Gibbons
	F.J.Van Doore*
Steno-secretaries	Miss S.Berkmann (Perth, WA)
	Miss M.Jarrett
Clerical Assistants	Mrs A.M.Krafft
	Miss Z.Katsis (Melbourne, Vic.)
	Mrs R.Osborne (Sydney, NSW)
Workshop, Animal Yards, etc.	
Senior Technical Officers	V.D.Townsend (Supervisor)
	R.R.Weste
Technical Assistant	R.J.Logue
Senior Laboratory Craftsmen	D.E.Bailey
	J.W.Prosser*
	B.L.Rumley
	R.M.Vial
Apprentice	P.P.Jard
Administration and General	
Administrative Officer	A.T.Scott
Clerk	J.S.Burrows
Clerical Assistants	Mrs S.I.Callus
	N.S.Eustice
	Mrs J.Francais
	Mrs B.J.Penman
Typist	Miss M.R.Howard*
Assistant (Transport)	J.W.Ward
Assistant (Food Services)	Mrs M.A.Colonna*
Labourer	J.D.Maddison*

Dairy Research Laboratory (DRL) — Highett, Vic.

Officer-in-Charge and Assistant Chief	L.L.Muller,BSc,FIDM,FAIFST
Administrative Officer	J.M.Ryan,BA (furlough)
	D.J.McCullough (Acting)
Scientific Services	
Scientific Services Officer (Industry Liaison)	Miss H.P.Dornom,BAgrSc
Librarian	Mrs S.M.Collins,AIAA,DipComm,Data Proc.
Clerical Assistant (Library)	Mrs J.A.East

Cheese Technology

Senior Research Scientist	G.W.Jameson,BSc,PhD (Research Leader)
Research Scientist	B.J.Sutherland,ARACI
Experimental Officers	Miss K.Nguyen Thi,BSc*
	H.J.van Leeuwen,DipAppChem
Technical Officers	R.J.Prince*
	R.M.Shanley,ARMIT
Technical Assistant	T.Mounsey

Biochemistry and Microbiology of Cheese

(†Located at Russell Grimwade School of Biochemistry, University of Melbourne)

Senior Principal Research Scientist	G.R.Jago,BSc,PhD (Research Leader)†
Senior Research Scientist	R.R.Hull,BSc,PhD
Research Scientist	A.J.Hillier,BSc,PhD†
Technical Officer	Mrs A.Roberts (part-time)
Technical Assistant	Mrs S.Toyne
Assistants (Laboratory Services)	Mrs H.J.Brown†
	Mrs N.Spurrell

Components of Milk as Ingredients in Foods

Principal Research Scientist	R.E.Timms,MA,PhD (Research Leader)
Senior Research Scientists	R.Beeby,ARMTC
	F.J.Kieseker,BAgrSc
	R.J.Pearce,BSc,PhD
Experimental Officer	D.A.Jones,BSc
Senior Technical Officers	W.P.Rogers
	P.D.Shimmin
Technical Officers	B.Aitken
	P.T.Clarke
Technical Assistant	P.Roupas*

Whey Utilization and Process Inter-relationships

Principal Research Scientist	J.G.Zadow,MSc,DAppSc (Research Leader)
Senior Research Scientist	Miss B.P.Keogh,MSc,FAIFST
Experimental Officers	J.A.Dunkerley,DipAppChem
	J.F.Hayes,BSc
	H.R.Kocak,BAppSc
	S.C.Marshall,DipAppChem,DipChemEng(grad)
Senior Technical Officer	G.Pettingill
Technical Officer	J.F.Hardham
Technical Assistants	N.W.Harris
	Miss R.A.Smith
	K.J.Woodruff§

Flavour Chemistry

Senior Research Scientists	E.H.Ramshaw,MA,PhD (Research Leader)
	G.T.Lloyd,BSc,PhD
	Mrs G.E.Urbach,MSc
Experimental Officers	J.F.Horwood,AGInstTech
	W.Stark,ARACI
Senior Technical Officer	E.A.Dunstone
Technical Officer	I.E.Barlow

Engineering Workshop

Experimental Officer	N.H.Freeman (Leader)
Senior Technical Officer	G.J.Vanderheiden
Senior Laboratory Craftsmen	B.W.Beere (Foreman)
	J.Fagan
	E.A.Green*
	W.P.King (Supervisor)
	R.V.Piper
	E.J.Ray (Supervisor, Laboratory Engineering)
Apprentices	D.Nilsson
	S.Revere

Process Bay

Technical Officer	J.J.Mayes
Technical Assistant	V.J.Mackie
Assistant (Laboratory Services)	G.W.Robinson

Administration and General

Clerks	G.Black*
	Mrs P.Fisher*
Clerical Assistants	B.C.Jones*
	Miss K.A.Treble
Steno-secretary	Mrs H.D.Appleton
Typist	Miss K.E.Egan

The following are stationed at North Ryde, NSW:

From CSIRO Division of Mathematics and Statistics

Experimental Officers	R.I.Baxter,BAgrSc,PhD (Section Leader)
	D.J.Best,MSc,DipMet
	Miss E.F.Smith,BA (part-time located at CSIRO Division of Applied Physics, Lindfield, NSW)
	Miss M.E.Willcox,BSc
Technical Assistant	Miss S.Clancy (part-time located at CSIRO Division of Applied Physics, Lindfield, NSW)

From CSIRO Division of Wildlife Research

Senior Research Scientist	B.S.Goodrich,BSc,PhD
Technical Officer	C.C.Reece

From NSW Department of Agriculture (attached to Plant Physiology Group)

Senior Research Scientist	K.J.Scott,BScAgr,DipEd
Research Scientist	N.L.Wade,BScAgr,PhD

The following is stationed (part-time) at Cannon Hill, Qld:

From CSIRO Division of Mathematics and Statistics

Experimental Officer	P.N.Jones,MSc (part-time located at CSIRO Division of Tropical Crops and Pastures, St.Lucia, Qld)

The following are stationed at Highett, Vic., as members of the ADC Technical Services Group:

From Australian Dairy Corporation	Z.Krapivensky D.Radford
From Asia Dairy Industries (H.K.) Limited	M.Gielen

*New appointment

§Government Special Youth Employment and Training Program (SYETP)